ISSN 2080-7279

FoM

2009 Volume 01 Number 01

FOUNDATIONS OF MANAGEMENT

International Journal

Faculty of Management
Warsaw University of Technology

Foundations of Management

Frequency: Published four issues per year; two regular and two special issues prepared by invited editor(s).

Internet: The International Journal - Foundations of Management is currently available on-line at:
http://www.wz.pw.edu.pl/s110/foundations-of-management.

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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.

We would like for the Foundation of Management to promote innovative scientific thought in the classical approach towards economic and engineering vision of the managerial sciences.

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

METHOD OF BUILDING MOBILE ORGANIZATIONS IN POLAND

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Abstract: We analyse concept of mobile organization which are characterized by personal approach to employees, strategies activating intellectual capital, open and interactive attitude focusing on values like teamwork and trust. Thanks to this, organizations in motion are effective in uncertainty, are better protected against losing and in case of difficulties can faster move on to the winning cycle again. In our project the main question to answer was – if there are any relationships between possessing features of a "young mobile and organization" and its competitive advantage. Based on the theory of managing change [4] it is shown that relationships between strategy, change and managerial competences are crucial for effective change implementation. From the viewpoint of management practice, the indexes developed and presented in this paper can be used to measure youth potential as well can be applied to analyse organizational change and improve the understanding of change among managers. They can be used in organizational audits. Using the indexes, organizations can be divided into Mobile Organizations, open to the environment, that can serve as models to others, and organizations that are more closed, immobile, with low youth potential. The latter require organizational revival projects to be prepared and implemented.

Key words: mobile organization, change, youth potential.

1. Revitalization of organization

In the conducted research[1], we were interested in the phenomenon of revitalization, also called rejuvenation of organization, necessary for its effective functioning of business in XXI century. It was assumed that high youth potential is characteristic of the so called *mobile organization* [7], the antitype to a static organization (remaining motionless). Generally a "mobile organization" has competencies that enable it to maintain or regain the growth stage of lifecycle. To simplify one may say that such an organization is **"young"** and **"open".**

Among its main features are:

- openness to environment, sensitivity to new signals and ability of diagnosing new circumstances, continuously being able to generate internal changes as the reaction to the above,
- handling uncertainty by creating people's positive attitudes toward the change,
- extension of „youth" phase by employing managers who have: energy, enthusiasm, courage, fresh look and who generate new ideas,
- ability to create organizational infrastructure and atmosphere which enable its members to be present in change (at all its stages),
- learning and investing in people as priority, which is transferred for HRD policy,
- implementation of systems which motivate people to be constantly involved in seeking ways of improving themselves and others so that their work is reflected in the companies' growing value.

One can assume that a mobile organization is a company which should be formed and supported in the future. It's able to build competitive advantage over others due to human intellect and profitable investments in the human capital.

In our project the main question to answer was – if there are any relationships between possessing features of a "young mobile and organization" and its competitive advantage. Mobile organizations are typified by strategies based on quality, technology and use of non-material resources. In order to obtain these resources, organizations design motivation and education systems that support changes and constantly observe employees' spirits. The research elaborated also on what the creation of mobile organization depends on and what determines their strategies. It was assumed that the elements essential for the strategists and their strategic choices are: market characteristics, strategic objectives of the company, and implemented or planned struc-

[1] Research grant financed by KBN (No 2H02D 004 25) and WSM included: prof. dr hab. Ewa Masłyk-Musiał – leader of the research team, prof. dr hab. Stanisław Sudoł, prof. dr hab. Grażyna Gierszewska, dr hab. Agnieszka Sitko-Lutek, dr Anna Rakowska and mgr Michał Jaksa.

tural/ownership and organizational changes[2]. Attitude to changes is therefore an indirect indication of strategists' preferences for specific strategies in companies.

The assumption made for the research was a relation between:

- type of organization distinguished on the basis of competences in changes, perception of changes, attitude toward changes and behaviour in changes,
- competitive advantage gained as a result of designing and effective implementation of a development strategy of a company.

The concept of mobile organization conveys a link between "the youth potential" and competitive position together with development strategies. It enables effective management under conditions of "general uncertainty" [6] also called "discontinuity management" by Ducker (1999). It also enables mobilization of the rare resources, including the intellectual ones. The concept of MO is useful for explaining activities leading to development of a good market position, choice and determinants of employees' familiarity with strategy, rejuvenating the organization, effective implementation of changes, counteracting to deterioration of managerial competences and maintaining constant readiness for learning, knowledge management, investing in education and building a change culture.

We believe that **mobile organizations gain competitive advantage thanks to use of their youth potential. Gaining high youth potential is possible thanks to effective competence management that guarantees appropriate strategic choices, effective change management and achieving strategic objectives even under conditions of distinctive uncertainty**.

It can be therefore assumed that the youth potential of mobile organization influences the competitive position of the company and its value for clients (effective implementation of the strategy). The bigger the youth potential is, the more clearly formulated, better executed, and more actively drawing on non-material resources the strategy of the company is.

Mobile organization shall cumulate and express all key elements of efficient management in turbulent environment: adequate reactions to new business situations, ability to learn and systematize knowledge (codification), and ability to search for support of new activities through execution of human resource strategies related with selection of personnel (especially executives), motivating, educating, and building change culture thanks to which employees can identify themselves with the organization often operating in uncertainty.

2. Subject and scope of research

The research focused on organizational changes introduced in Polish companies within certain competition strategies and managerial opinion[3] on the changing process. Both companies and their managers performed in business environment specific for our country in 2004, when for nearly fifteen years the companies had been gathering knowledge about great constitutional and economic transformation. Tangible expressions of these transformations in organizations were multiple restructuring processes often defined as introduction of strategic organizational changes.

Some of researched companies were restructured public enterprises, operating in mature sectors and with a long history (some were set up in the fifties, several even earlier); some of them were new companies, established after 1990 and operating in developing sectors. The latter constituted 64,6% of the sample group.

We were interested in what happened in the old companies during constitutional transformation and what influenced their present organizational competences and market position. Are companies set up after 1990 characterized by, figuratively speaking, youth, and have the old companies managed to restore this condition which could be proved by energy, fresh perception, creativity and courage of employed executives?

We believed that among both types of companies, the old and the so called rejuvenated, there are ones with characteristics of mobile organizations and competent in change management. We assumed that thanks to their "youth", companies are able to achieve better competitive position. However, not all companies succeeded in "youth" restoration throughout fifteen year period (time between transformation of 1989 and

[2] E. Masłyk-Musiał, G. Gierszewska, Strategies of Revitalized Organizations in Poland – Research Result, 22nd EGOS Colloquium Bergen, Norway 6-8 July 2006.

[3] Selection of companies and executives was nonrandom. Research on the subject of changes and competences covered 275 executives and additionally 84 of them answered questionnaires concerning company strategy. Three sorts of questionnaires were used: strategy one was prepared for company strategists, the other two (focusing on 1. executive competences, 2. change and competences issue) were used in interviews with executive personnel being in touch with changes. Researched businesses (40 companies) were chosen among businesses from sectors diversified as to the cycle of life (young and mature sectors) and as to the technological development.

the beginning of the research in 2004). Changes were imposed on them but have not become style of living. A question whether accumulation of knowledge about certain regularities observed in a process of numerous restructuralizations transformed Polish companies into mobile organizations and therefore organizations with huge youth potential seemed to us an intriguing research issue.

In the research it was attempted to estimate the development potential of the companies, and then the relations between this potential and strategies executed for gaining the competitive advantage were analyzed. It was deliberated what strategies should be implemented by a company in order to retain "eternal youth" enabling prolongation of the phase of quick absorbing and generating changes in the life cycle of an organization, and with this – consolidation of the competitive position.

Outcome analysis proved how many possibilities of creating grounds for competitive advantage there are globally, and locally, what can become a success factor for a company and how specific companies with specific development potential can achieve it.

3. Attitude to changes

It was assumed that the attitude of respondents toward changes[4] is a resultant of their perception of situation when changes occur and their competences. Change situation is also defined by: kinds and reasons of changes, participation in changes, change stimulation, perception of forces supporting changes and effects of changes. Owing to the features of particular businesses (like their size, age, business profile, etc.) the strategists' and managers' attitude toward changes will vary. It was also assumed in the research that attitude toward changes influences orientation of strategic choices.

3.1 Areas and reasons of changes

According to questioned managers, in 2000 - 2003 numerous organizational changes were introduced in companies they were employed in. Implementation of changes was noticed by 95,9% of respondents. Only 2,3% of questioned managers believed that their companies were not implementing any changes, and 1,8% had no opinion on that subject. 84% of respondents mentioned change planning in 2004 - 2005.

Most common areas of changes indicated by the managers as implemented in their companies included: organizational structure (76,7%), general strategy (47,4%), technology (46,3%), motivation systems (40,7%), and information-decision systems (36,3%). Indications in planned changes included: organizational structure (48,1%), technology (43,7%), information-decision systems (35,2%), functional strategies (33,0%) and general strategy (31,5%). There is an essential statistical correlation between age of a company and the genre of implemented and planned changes. In reference to implemented changes it concerns functional strategies ($p = 0{,}001$), technology ($p = 0{,}006$) and motivation systems ($p = 0{,}000$), and in reference to planned changes it concerns organizational structure ($p = 0{,}000$).

When analyzing correlation between company age and area of implemented changes, it can be observed that managers employed in middle-aged companies (set up between 1980 and 1989) more likely than managers from young and old companies indicated changes in functional strategies. 66,6% of respondents from middle-aged companies indicated such changes, while from young businesses only 52,6% and 31,0% from the old ones.

Technology changes were most often noticed in old companies (59,8% of research sample), meanwhile changes in motivation systems in middle-aged (53,3%) and young companies (51,4%). Changes in organizational structures were planned first of all in young (56,1%) and old companies (37,9%). Therefore, in respondents' view old companies changed technology, middle-aged – functional strategies and motivation systems, and in young ones changes in organizational structures were planned. The above indicates that managers distinguish the need of making their businesses more flexible, which involves complementary changes in structures defining shape of an organization. In such cases structural change means improvement of company's openness and entrepreneurial approach.

It is worth noticing that both strategists and managers of changes indicated (first two places) changes in the same areas (see table 1). Respondents listed first of all: organizational structure (67,9% of questioned strategists and 76,7% of managers) and general strategy (54,8% and 47,4% respectively). Further places were

[4] Report covers the respondents' attitude toward changes implemented in their companies in 2000-2003 and changes planned in 2004-2005.

taken by areas of changes either different in both groups or listed in a different order. For the strategists these are: objectives of organizations, information-decision systems and changes in management methods, while managers listed: technology, motivation systems and information-decision systems.

Both position occupied in the organizational hierarchy and connected responsibility for changes (role performed in change process) strongly reflect on perception of changes implemented or planned in organizations as well as on assessment of their importance for company's success.

Questioned executives indicated following external factors as mainly inspiring companies to implementing or planning organizational changes (ordered as indicated by the respondents):

- entrance of competitors – 49,6%,
- new, more effective technologies – 44,4%,
- changes in international politics (i.e. entering EU) – 34,4%,
- changes in economic management methods and restructuralisation – 28,5%,
- changes in legislation and changes in forms of ownership – 27,4%.

There is a statistically important correlation between company's age and the causes of change like changes in international politics ($p = 0{,}001$) and new, more effective technologies ($p = 0{,}003$).

In young companies directors more likely than in others, especially in middle-aged, indicated these particular external causes of change. It can be therefore assumed that young companies are more open to the world and their executives see this openness as an opportunity for their companies' development as well as necessity of change implementation.

However, they are not always able to define the required competences. There is a feeling of readiness to changes in the companies, which is however not necessarily tantamount to the ability of their effective implementation.

Main internal causes of organizational changes indicated by the respondents were:

- too slow development of new products – 34,1%,
- used machinery - 31,1%,
- lowering quality level – 18,5%,
- decrease in productivity of assets - 18,1%,
- decrease of work effectiveness – 17,4%.

Statistically important correlation is observed between company's age and the internal causes of change like too slow development of new products ($p = 0{,}00$) and used machinery ($p = 0{,}01$). The former reason was noted mainly in young companies, the latter in the old ones with used machinery.

Despite large group of respondents who noticed changes in the companies, many executives are not able to see the relation between changes and company's strategy. Over 20% is not familiar with the latter, which means every fifth respondent. This however does not mean they don't see into the future of the company in bright colours. The analysis of opinions of different management level representatives shows that 76% of high executives, 64% of middle management representatives and 45% of low managerial staff is optimistic about the future of a company (degree of optimism grows with the management rank).

This can be regarded alarming, especially in reference to high executives as exaggerated optimism can be a testament to carelessness or lack of competence (much of a muchness). Strategists' opinions seem to confirm the above, as only in 30% of businesses a clear strategy has been tracked (meaning cost-leadership, quality or combination strategies), the rest had no coherent strategies or no strategy whatsoever. 16% of respondents had no information about changes planned in the company in the two proceeding years.

Taking no knowledge about the company's strategy (actually – no strategy at all) into account, it can be assumed that the need to plan changes might not be obvious for part of managing staff. Meanwhile, creation and awareness of a strategy showing direction to company's managers and helping with uncertainty, is a high-priority matter for a company.

Even maintaining current competitive position requires from the executives the ability of strategic thinking and planning changes, not to mention acquiring additional competences for gaining competitive advantage in the future. However, how aware of this are the questioned managers and what are their competences?

3.2 Participation in change and change competences

Literature analysis [7] shows that to make changes effective, the companies should have organizational

Table 1. Comparison of most frequently noticed changes by the respondents performing roles of strategists and managers (in percentage) *(source: self study, 2004)*

Strategists' opinions (n = 84)						**Managers' opinions** (n = 272)	
Product changes		**Structural/ownership changes**		**Organizational changes**		**Organizational changes**	
Broadening product offer	69,0	Changes of internal structure of a company	42,9	Change of organizational structure	67,9	Organizational structure	76,7
Improvement of product quality	58,2	Differentiate customer service	40,5	Change of general strategy	54,8	Change of general strategy	47,7
Introduction of cost monitoring	53,6	Eliminating certain areas of monitoring	27,4	Change of organization goals	45,2	New technologies	46,0
Developing promotion and advertising	48,8	Improvement of ownership changes	23,8	New information-decision systems	44,0	New motivation systems	40,7
Reducing unit production costs	47,6	Creating partnership based on the company property	22,6	Change of management methods	41,7	New information-decision systems	36,3

competencies in terms of changing that create conditions for participation in changes for employees and especially – managers, and executive competences in changes. Conditions for employees' participation in changes are: encouraging to participate in initializing, designing and other stages of changing, systematic and honest informing employees, developing their abilities to perform at changes (training in changes), effective motivation to changes (gratification for acting the new way). Important organizational competence in preparing for change and ensuring active participation in the change process is creation of change culture awarding values like trust and courage, and behaviours like willingness to take risk and sharing ideas with others, which is necessary for team work and getting satisfaction from implementing changes.

In respondents' opinion, changes were implemented in companies most frequently on board's initiative (88,5% of indications), executives (32,6%) and internal consultants (19,6%) or external directors employed for this purpose (3,7%). Initiatives from individual employees were very rare (5,6%). More often the initiators were employees groups (10,4%) or company's specialists (13,3%).

Majority of changes were thoroughly prepared, according to 76,7% respondents ("yes" or "rather yes" responses). Only 16,4% of respondents believe that the changes were rather unprepared, and 3,9% find them unprepared. 3% percent of executives have no opinion on that issue. There is a statistically important correlation between the age of a company and a statement that changes were initiated by consultants (p=0,002) and carefully prepared (p=0,001), and also between size of a company and designing changes (p=0,03). 25,7% of executives in young companies point out important role the consultants play in changes, while in the old companies it's respectively 9,2%, and in middle aged companies 6,7% of questioned directors. In young companies 83,3% of questioned executives answered affirmatively ("yes" and "rather yes" responses) to questions if change processes in the company are planned carefully and in advance. In middle-aged companies this rate was 79,9% and in old ones – 60,5%.

Taking company's age into consideration it can be noticed that 82,1% of executives from big companies believe that changes and thoroughly prepared ("yes" and "rather yes" responses), in medium-sized companies it is 74%, and in small ones – 72,3%. The conclusion is that in small companies executives rarely find changes thoroughly prepared. The biggest number of respondents participated in implementation stage (86%) and in preparation of change projects (70,8%). Size and age of a company influence participation in change. 77,2% of questioned executives from big companies indicate their participation in initiating changes.

In medium-sized companies we received such response from 56% of questioned directors and in small ones – from 43%. In general, observation of percentage distribution of executives' responses, allows a notice that

apart from training stage, where medium-sized companies' directors are more active, the most active executives in the remaining stages are – in the following order – ones from big, medium-sized and small companies. Taking company's age into consideration, we notice that in initializing and implementation stages most active executives come from middle-aged, then young and finally old companies, and in preparation and evaluation stages – executives from respectively young, middle-aged and old companies.

60,5% of respondents participated in trainings prior to the changes. This is a pity that this percentage was as low as the participants of trainings evaluated the effectiveness of changes higher, regardless of their own evaluation of usefulness of trainings conducted in relation to changes.

Their participation in trainings prior to changes was described by the respondents as useful (response "very useful" was indicated by 27,2% of respondents, "useful" – by 50,0%, and "rather useful" – by 19,3%). Only 3,5% of respondents found trainings "rather useless". 75% of respondents indicated that in connection to changes in their companies, the trainings were organized for the whole (or selected) staff, which was considered a very positive phenomenon. Trainings are most often organized in young companies established after 1989. This is a statistically important correlation (p=0,01).

Every fifth manager in all researched companies responded, however, that training related to introduced changes was not held in their companies, and 5% of managers answered "I don't know". One fourth of managers, in situation of change implementation, did not observe any high executive's interest in employees' development. This is another indication of insufficient, in several researched companies, information delivered to the employees (in this case trainings are not exploited) about the current situation in the company during organizational changes and not caring about creating effective motivation (including dialogue and trainings) system simultaneously to change implementation.

Organizational competences were indicated by the strategists (strategy interview), and managers' competences were revealed in their auto-evaluation (competency interview). Table 2 presents competences sheet with competences indicated by the research participants supplemented with competences existing in theory of change.

Table 2. Competences sheet – most important organizational competencies, managers' competences in own research (%) and in theory *(source: self study, 2004)*

Organizational competences important for changes – researched strategists' opinion	**Managerial competences important for change implementation – researched managers' opinion**	**Managerial competences in organization in motion – theoretical approach (Kanter, 2001)**
Engaged employees (41,7%)	Focus on the future (65,8%)	Easy adaptation, flexibility
Effective change management (39,3%)	Multi aspect approach (50,7%)	Entrepreneurship and innovation
Effective finance management (36,9%)	Developing and mastering employees' competences (43,5%)	Knowledge sharing
Feeling of trust and cooperation (36, 9%)	Discovering new products and markets (36, 7%)	Facilitating team work and understanding other groups contribution to changes – art of building relations
Information sharing (31,0%)	Social skills like leadership, communication, conflict solving (34,9%)	Ability to implement changes effectively – removing obstacles in changing process

The above chart shows discrepancies between theorists' opinions (literature studies) and point of view of strategists and managers (research outcome) who often play double role of leaders and change agents, as to the organizational competences and managers' competences that are necessary for efficient change implementation. Theorists' competency list begins with easy adaptation and flexibility, strategists' with engagement of the employees, and managers' with focus on the future. Entrepreneurship and innovation is listed by the theorists on the second position. Managers find competences related to entrepreneurship, like discovering new products and markets as less important and locate them on only the fourth place.

When naming competences indispensable for efficient changes in a company, strategists indicate general idea of creating feeling of trust and engaging employees in change process, and therefore pay attention to personal approach to employees during changes, and care about appropriate use of resources, in particular financial ones, in changes. This means that during changes they focus on: staff, knowledge (effective management) and resources. Mangers look at change implementation from perspective of accomplishing task in changes, which means the most important competences for them are: ability to learn and analyze needs, as well as organizing training processes. Since change process can provoke conflict situations, other important competences indicated by managers were: negotiations and conflict solving.

Despite of different focus, the attitudes to changes expressed by strategists and managers seem to be supplementary.

Competences pointed out by them are compliant with theorists' suggestions that mention following essential abilities for changes: sharing authority (with respect to strategists' suggestions) and ability to build teams and maintain appropriate inter-group relations (with respect to managers' opinion). This data again indicates visible influence of the organizational roles on the opinions about organizational and managers' competences essential for effective changing processes, by assumption related to (but not de facto as according to strategists' responses, in about 70% of companies, the strategies were not coherent or unspecified) specific development strategies.

The managers' own competences in change management were best evaluated by those from the youngest companies (28,8%) set up after 1990. The worst evaluation in that category was assigned to the managerial competences in companies established between 1989 and 1990 (6,7%), and a slightly better one to the oldest companies (set up before 1989) – 14,6%. It can be therefore assumed that managers in young companies have better competences than managers in other organizations.

It results from the research that managers believe they are competent in: problem solving and decision making (72,9% of respondents), predicting and planning (58,8%) and using expert knowledge (58,7%).

They find these competences sufficient as complex dynamic situations rarely occur in their work. Researched managers indicate that what their tasks require is rather constant learning (48%) and advancing employees competences (47,8%), also maintaining good relationships with business partners (46,6%), and not focusing on the future or multi-aspect analysis of decision situations. It was observed that only one fourth of researched group admitted being competent in change management (this refers mainly to young companies – important statistical correlation), and only every third respondent would like to improve the competences. Such observation allows assumption concerning dominance of operational orientation over strategic one amid our group of respondents.

3.3 Effects of changes and their determinants

In the research we were interested in managerial opinions on the effects of introduced organizational changes. 65,5% of managers believe that changes ended up successfully. Among young companies managers 70% assessed the changes ended up successfully. In old companies 57,1% of respondents believed so, and in middle-aged companies – 46,1%. The biggest number of unsuccessful changes was reported by managers from old companies.

Belief that changes did not end successfully was expressed by only 6,0% of all respondents. As many as 28,5% of them (over one fourth) responded "I don't know" or "hard to say", which indirectly shows lack of conviction as to the success of implemented changes. Such opinions appeared mainly in middle-aged companies where over half of managers gave evasive answers like "hard to say". Reasons of such hesitancy can be various but most often are: lack of tools for assessing effects of changes (it is not clear what is actually result of changes and what would have happened in the com-

Table 3. Factors influencing effective implementation of changes in the opinion of strategists and managers from researched companies *(source: self study, 2004)*

Factors which influence for the changes efficiency **in the opinion of strategists**	scale (1- 5)	Factors which influence for the changes efficiency **in the opinion of managers**	scale (1- 5)
Managers Engagement	4,28	Managers Engagement	4,28
Level of managerial knowledge	4,09	Level of managerial knowledge	3,92
The amount of financial resources	3,99	Workers skills	3,80
Workers skills	3,78	The amount of financial resources	3,65
Understanding of change need by workers	3,72	Change scope and depth	3,53

pany anyway), and no routine informing employees about results of changes. It is therefore clear that managers underestimate motivation as system tool strengthening changing process. Strategists and managers in researched companies indicated different factors that influenced effective change implementation in their companies (table 3).

Order and consequent meaning of these factors for success of changes was established basing on an average from five point scale of influence.

Both strategists and managers indicated involvement (average 4,28 and 4,28 respectively) and level of managerial knowledge (4,09 and 3,92) as main factors of change success. On the third place strategists placed financial resources (3,99), while managers – employees' skills (3,80). For managers the scope of changes (scope and depth) was also important (3,53) but for strategist it was more important that the necessity of change was understood by their receivers (3,72) who could thanks to this become allies in change implementation. Thus, strategists and managers agree as to the essence but differ when it comes to details. Again, as when indicating areas of change, there is correlation between the rank of management and roles played in changes, and opinions about them, and this time it refers to change success factors.

3.4 Stimulating changes

In successful change management models a correlation between strategy, structure, organizational culture and compensation system oriented to supporting changes is often pointed out. Appropriate connection of these factors in different stages of organization life cycle allows efficient execution of company strategy and achieving better results called change added value (Berger et al., 1994).

34,8% of the respondents gave affirmative answers to the question "Are the employees in your company extra rewarded after completing tasks related to changes?". 51,7% gave negative responses, and 13,5% had no information on that topic. Managers who noticed correlation between remuneration and tasks accomplished during changes most often named three forms of remuneration encountered in their companies: individual bonuses (29,3% of respondents), oral praise (19,3%) and special rewards (14,8%). In reference to the latter two, a statistically important correlation occurs between them and the age of a company: younger companies more often apply these forms of remuneration in situation of changes.

4. Indexes of Organizational Youth (IOY)

Defining the features that describe a mobile organization helped formulate the index defining the potential of organizational youth (**POY**). POY was developed on the basis of two sub-indexes: Index of Managerial Change Potential (**IMCP**) and Index of Managerial Youth Potential (**IMYP**). Together, they determine the potential of organizational youth. The results of these indexes are presented in the table 4.

The **Index of Managerial Change Potential (IMCP)** was developed on the basis of 10 constituents relating to change and competences, perception of change, attitude o change and motivation to act in this respect. We made an assumption that in mobile organizations the employees see organizational change both as it is implemented and planned, and take a positive view on the effectiveness of the change. The change is extensive and covers various areas of the organization. Managers in the organization are optimistic about its future and are committed to change, feel motivated and the organization invests in their development.

Table 4. Distribution of sub-index values determining potential of organizational youth of Mobile Organization (POY) *(source: self study)*

1.	2.	1+2	
Index of Managerial Youth Potential **(IMYP)**	Index of Managerial Change Potential **(IMCP)**	Potential of Organizational Youth (**POY**)	**POY** Level
H	H	2H	High
A	H	H, A	Relatively High
H	A	A, H	Relatively High
A	A	2 A	Average
L	H	H, L	Average
H	L	L, H	Average
A	L	L, A	Relatively Low
L	A	A, L	Relatively Low
L	L	2L	Low

The **Index of Managerial Youth Potential (IMYP)** was developed on the basis of five constituents: commitment to change, optimism, indication of significant skills in making change (e.g. focus on the future, discovery of new products, markets, conceptual skills, learning, risk taking), possessing change management competences in self-assessment.

Index of Managerial Change Potential (IMCP)

1. The results for 40 organizations indicate a relatively low managerial change potential. For 16 companies IMCP is above average and so they can be included among organizations with average change potential. One of the organizations is on the border line of high change potential, and three are above average.
2. It was observed that **IMCP is connected** (chi^2 = 0,000) with the following features of the respondent organizations:
   - **scope of business** (IMCP is the highest in national organizations),
   - **type of production** (IMCP is the highest in companies engaged in the provision of services and the manufacturing of consumer products),
   - **legal form** (IMCP is the highest in all types of companies and partnerships – limited liability company, joint-stock company and civil partnership and the lowest in state enterprises),
   - **type of business** (higher IMCP is reported in service, financial/insurance and construction/trading organizations),
   - **age of organization** (higher IMCP is reported in young and adult organizations).
3. **IMCP is not high in construction organizations (old industry), local organizations and sole proprietorships as well as state enterprises.**
4. The percentage distributions show a large number of managers (nearly 60%) with low IMCP in old organizations and nearly 50% in adult organizations.

Given the incidence of low managerial change competences, the above information is hardly good news. While young companies, by effective selection of managers, stand a better chance to rebuild or supplement this potential, the task will not be easy since nearly every third manager has a low IMCP. We have to bear in mind that some of the managers do not know the strategy, have an operational orientation, and are not interested in the future.

Index of Managerial Youth Potential (IMYP)

1. The other sub-index of the potential of organizational youth is the Index of Managerial Youth Potential. The values reported for IMYP are at an average level. In 4 organizations the index was above average (industry: branch of an IT multinational, medium-sized consumer electronics company, large food products company, medium-sized automobile manufacturing and sales company, however these are different companies than the ones reporting a high IMCP. The highest IMYP index was reported in a large IT company in which the managers scored even the highest level of IMYP. The maximum level of the index was also reported for individual managers in 3 organizations. For other managers in these companies the index was low which is a reflection of large differentiation of ma-

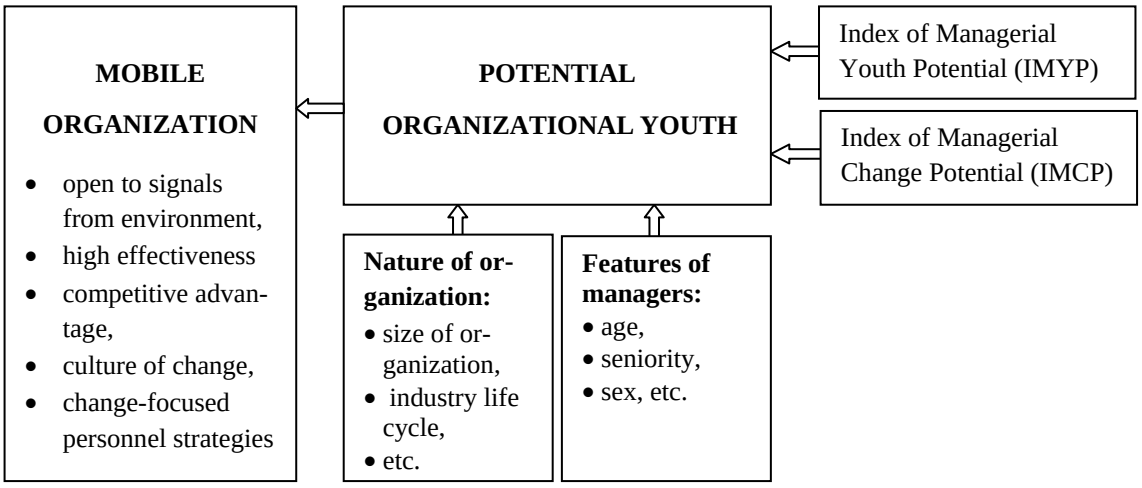

Figure 1. Relations among Variables *(source: self study)*

nagerial potential in the same organization and perhaps also of the need to change the personnel policy

2. A high IMYP was reported in companies with an average (up to 300) and high (over 301 employees) **number of employees**. The relationship is statistically significant (chi^2 = 0,03). The percentage distribution of managers in a group with high youth potential is as follows: in medium-sized organizations 50,0%, in large 44,7% and in small 5,3% of the respondents.
3. The more extensive the **scope of business**, the higher IMYP (chi^2 = 0,000). Organizations in which managers report high IMYP offer services and consumer products (chi^2 = 0,003). The type of business includes services and industrial (chi^2 = 0,000), with a domination of companies and partnerships (chi^2 = 0,002).
4. At the higher **levels** of management, managers report a higher IMYP. High IMYP occurs also at lower levels of management and such managers, in our opinion, should be promoted first.
5. **Age of Organization**. The adult organizations report most managers with a high IMYP (20,0%) and in young organizations, set up after 1989, 17,1% of respondents demonstrate high IMYP. Managers (45,1%) in old companies, established prior to 1980, report a low managerial youth potential.

We made a preliminary assumption in the project that the age of respondent managers and their seniority in the position held may be connected with the Managerial Youth Potential. However the findings of research did not confirm that assumption.

We were also interested in the relationship between **IMCP** and **IMYP** which is presented in Table 7.

One quarter of the respondents report both high IMYP and IMCP. The group of mobile managers with change competences and high youth potential in the project is therefore relatively high (chi^2 = 0,000).

Still more numerous however is a group reporting low IMYP and IMCP. The most numerous is the group with average IMCP and IMYP. High IMCP is never accompanied by low IMYP. Low IMCP is most often associated with low and average IMYP.

Summing up the analysis of the relationship between the properties of the organization and features of respondent managers, and IMCP and IMYP of the respondents, it should be stressed that **there are statistically significant relationships between IMCP and IMYP** and certain properties of the organizations and features of their managers. As indicated by the earlier analysis, higher IMCP and IMYP occur more frequently in national organizations set up after 1989, that is in the young organizations.

Index of Organizational Youth (IOY)

The application of the full IOY helps differentiate organizations in terms of their youth potential, location of the organization on a continuum between mobility and immobility, and then propose a youth maintenance or restoration programme. IOY measuring the potential of organizational youth may help make the management aware of the need to take action to reinstate youth which is necessary for an organization to effectively compete for the customer and be open to the signals from the external environment.

In order to win battles with competition, organizations must have youthful energy, openness and confidence in themselves, others and the system facilitating, as R. Kanter [5] puts it, practising cooperation, innovation and responsibility.

Over one half of the reviewed organizations demonstrate an average youth potential. Only two organizations have a relatively high IOY and therefore can be recognised as mobile organizations (**electronics and IT)** and their behaviour in change treated as a model (benchmark) for other companies. These companies are young in two ways: firstly due to the actual age (young branch in Poland) and secondly due to their youth potential.

If we take the change process seriously, then – rather than from imposing ready-made change patterns – we will start the process of change from preparing tailor-made projects. This requires a measurement of the potential of organizational youth and stimulation of the interest in change among all the change beneficiaries.

The opening up of an organization to challenges through unleashing human potential is both necessary and the most difficult task for change strategists and leaders.

Table 5. IMCP and Age of Organization (%) *(source: self study)*

IMCP / Age of Organization	Low	Average	High	TOTAL
Old	57,3	40,3	2,4	100
Adult	46,7	40,0	13,3	100
Young (set up after 1990)	**30,7**	**52,8**	**16,5**	**100**

Table 6. IMYP and Age of Organization (%) *(source: self study)*

IMYP / Age of Organization	Low	Average	High	TOTAL
Old	45,1	48,8	6,1	100
Adult	33,3	46,7	20,0	100
Young (set up after 1989)	**24,0**	**58,9**	**17,1**	**100**

Table 7. Relationship between level of IMCP and IMYP in respondent managers (%) *(source: self study)*

IMYP / IMCP	Low	Average	High	TOTAL
Low	**55,6**	37,0	7,4	100
Average	18,8	**64,7**	16,5	**100**
High	0,0	75,8	**24,2**	100

Table 8. List of Organizations and IMCP/IMYP Relationships with Other Variables of the Project *(source: self study)*

Index	Numbers of highest potential organizations	Statistical relationship between organization potential and properties
IMCP	10, 32, 38	Scope of business, type of production, form of ownership, type of business, **age of organization**
IMYP	6, 8, 11, 33	Scope of business, type of production, form of ownership, type of business, **age of organization** and size of organization

5. Summary

Mobile organizations are characterized by personal approach to employees, strategies activating intellectual capital, open and interactive attitude focusing on values like teamwork and trust. Thanks to this, organizations in motion are effective in uncertainty, are better protected against losing and in case of difficulties can faster move on to the winning cycle again [5].

From the viewpoint of management practice, the indexes developed, used to measure youth potential, can be applied to analyse organizational change and improve the understanding of change among managers. They can be used in organizational audits.

Using the indexes, organizations can be divided into Mobile Organizations, open to the environment, that can serve as models to others, and organizations that are more closed, immobile, with low youth potential. The latter require organizational revival projects to be prepared and implemented.

The MOs highlighted by the research are young organizations, set up after 1989 and operating in young industries. They have clear (to strategists and managers) development strategies, effectively introduce change, create conditions for everybody to participate in the change process, and invest in staff development. These organizations are open to the future, to constant change.

Organizations with high youth potential employ and develop managers with high youth potential. They select change-focused managers with change management competencies. MOs are aware of the relationship between the strategy and personnel policy. More often than in the other respondent organizations, in parallel with structural change, MOs introduce changes in compensation systems. Development of people is an important management staff appraisal criterion.

Managers have varied management competencies. The worst-performers are the traditional industry managers, while two foreign-owned high-tech companies reported best results. The management in these companies have among others good change management skills, good personality potential and high level of IT application knowledge.

The age of organizations is positively correlated with change management skills and management staff development, which confirms the impact of the new organizational culture; the older organizations still apply the traditional approach to management.

However, part of "traditional" businesses in Poland remains under governmental protection and operates in non-modern sectors. They have learned how to resist changes, especially those of which scope and implementation they were not able to influence. In our research on organizational "motion" public enterprises in traditional industries came out slightly worse.

The situation differs in high technology sectors where winning depends on constant search of new, better products, creation of new markets and constant learning. Two companies (codes as: F06 – utility electronics, and F33 - informatics) that can be considered organizations in motion operate in such sectors. The companies are young in two dimensions – first of all because of their age (in case of the second company it's not the age of the company but of its branch in Poland), and second of all because of their high youth potential.

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INFORMATION AND KNOWLEDGE MANAGEMENT AS A NEW PHASE IN MANAGEMENT THEORY DEVELOPMENT

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Abstract: The article presents the following hypothesis: currently we are witnessing a creation of a new management concept in organizational science and management. This concept, which was created after the system concept, can be called the information or knowledge management concept. It was created and is developing due to the development of IT (Information Technology). It is the result of a certain need connected with the development of management science and progress in economical sciences and IT technologies. Problems of electronic economy, the most dynamically developing branch of global economy, require quite a different approach than in current management methods. Therefore the development of this concept is linked with the development of IT and management methods connected with it.

Key words: Information, knowledge, management, management theory development, organizational science, Information Technology, e-commerce, virtual technology, virtual organization.

1. Hypothesis and its justification

At the turn of XX and XXI century many qualitative step changes in the development of Management sciences took place. The following hypothesis can be presented:

A new theory was created in the science of management, which is different from previous management theories (classical, behavioral (psychological), quantitative with system approach). The fact that differentiates this theory from the others is a stress on information and knowledge management. It can be named as the information and knowledge management theory, what seems to be the most suitable definition or in a simpler way but with attention to the basic features of knowledge management.

Literature of the subject distinguishes the basic management theories (or directions) such as: classical, behavioural and quantitative with system approach (see [20, 16, 38]). Creation of the first ENIAC computer as well as development of the computer industry contributed to the development of the latter concept.

Current direction, similarly to the quantitative theory with system approach, is connected with the development of modern Information Technology. However modern IT faces different problems and has entirely different solutions than 50 years ago. In the beginning of IT development there were no such tools as the Internet, data banks, databases, multimedia systems, virtual technologies.

Presented article is a continuation of earlier deliberations over this issue (see [22, 25, 26]). After these publications the author supported in relation to the correctness of presented hypothesis and decided to develop it.

2. Characterization of the new theory

The new theory, which is usually defined as information and knowledge management theory, is created as:

- response to practical need connected with the creation of information society, which includes the creation of new organization functioning forms and the new role of an employee in a modern enterprise as well as the necessity to use such management methods and techniques that allow risk and change management; this allows dynamic decision making in the changing environment, which is defined as turbulent, virtual or elusive in the literature,
- on the other hand, it is created on the basis of possibilities provided by the rapid development of IT technologies such as the Internet and the creation of supporting systems like BI and e-BI, ERP-II and other e.g. agenda systems; due to the advanced and developing IT tools it is possible to meet all requirements of the customer.

However, the new theory brings threats and ethical issues (cyber terrorism and black PR are only an example of such threats). This issue will be described in detail further in the article.

If one would take the disciplines, from which the biggest number of applicants was awarded the Nobel Prize, for the determinant of the development of selected scientific discipline, it should bring to a conclusion that information technology is the most rapidly developing science. These awards, usually connected with economy and physics, show many significant activities taking place in the world of information technology and the applications of this technology.

Fundamental works of authors such as P. M Sanga, I. Nonaka, H. Takeuchi, E.A. Feingenbaum, A. Jashapar, A. Tiwan and many others, are a part of the global canon of knowledge management. Many of such elaborations are also created in Poland.

If one would took a closer look at the situation in Poland, he would discover that the subjects of recently organized conferences, scientific seminaries, published monographs, articles and publications in magazines such as HBR, Manager Magazine, Computerworld are concerning mainly information and knowledge management.

Many publications from this field of science include A. Koźmiński and P. Jemielniak [17], W. M. Grudzewski and I. K. Hejduk (red) [13], J. Kisielnicki [27], S. Forlicz [9]. L. W Zachera [2008 – jubilee journal], K. Perechuda [34]. There are many more publication in this matter and the listed authors include only a small part of the ones that are most recognized (this article was submitted in the January of 2009). This article will not deal with the relations between management science and other social sciences. Readers interested in these issues should read the elaboration by S. Sudoł [39] or the opining submitted by W. M. Grudzewski [13] for the purpose of Organization and Management Committee of Polish Academy of Sciences.

Global literature frequently uses the term "new economy" for current period (J. Schermerhorn in [38] uses the more appropriate term of modern management).What is the essence of new economy and modern management? The essence of new economy is the use of Information Technology in information management process as well as knowledge management processes. Similarly to most of Organization and Management Committee of Polish Academy of Sciences members [committee meeting reports from 2007 – 2008) the author claims that management should by now separate itself from economic sciences. In further deliberations the term of modern management is used.

Did the proper time for the functioning of the new theory have already come or are we witnessing the creation of it? However, what is proven in the article, changes in the theory and practice of management are significant, that is why one can speak of creation of the new concept. Even though the concept is connected with the traditional management theories, especially with the quantitative with system approach theory, it can be acclaimed as an independent concept. The term E-management is not used in the article not to limit the analyzed concepts only to the issues connected with Information Technology. The development of IT technology is significant what can be observed in the influence of the Internet on the new management directions [35]. IT gave a new impulse to the organizational and management sciences and forced us to reinvent our approach towards management theory.

When analyzing the previous experience of organizational and management sciences one assumes that it was dealing with the following problems in all of its development phases:

- efficiency (actions of humans are rational – it is the paradigm of the classical theory including scientific management and ideal bureaucracy),
- motivation (people seek ways to improve their place in the society, properly motivated the can "lift mountains" – the basis of psychological or behavioral theory also known as social and human resources management),
- decisions (people aim at taking the right decisions in existing conditions – the leading direction in the quantitative with system approach theory).

Aiming at the management in the conditions of complete information is one of the common trends. Information is a specific resource, which allows to solve issues connected with the lack of other resources.

Management is a social science that deals with decision making in the situation of lack of resources such as: land, workforce, capital and drive and initiative. These decisions should also include the practically unlimited needs and requirements of the society. To fulfill such needs and face the lack of resources many different decision making procedures are used, which deal with the allocation of the limited resources. Modern management theory, supporting the economical sciences in this matter, deals with the decision making process that answers the following question: How does the modern society deal with the lacking resources?

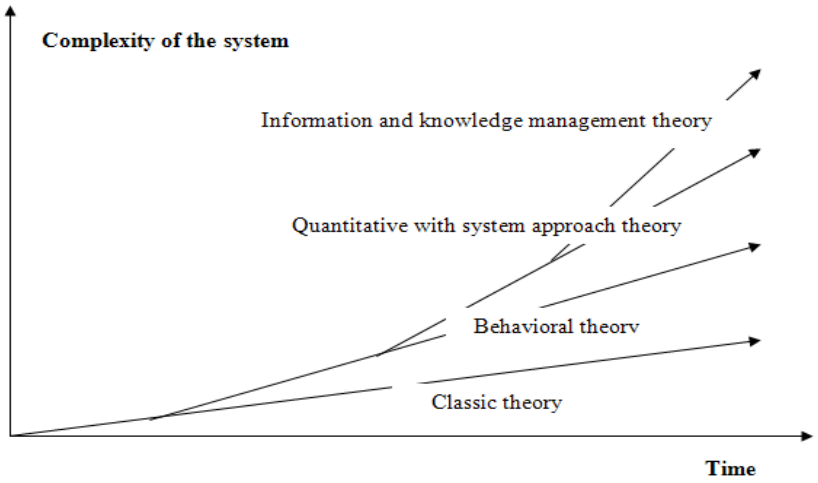

Figure 1. Development of management schools *(source: self study)*

Solutions connected with information management, including knowledge management, contribute to the more efficient solutions for modern world problems. Due to Information Technology, especially global computer networks, we are operating in cyberspace.

Cyberspace is created by two basic elements:

- heterogeneous computers localized in different places of the physical space that are able to receive and transfer information,
- global computer networks able to transfer information.

Relations existing between these elements have the form of various relationships and are determined with existing procedures and communication protocols. Lack of possibility to determine the boundaries with physical measures and multi-directions of relations are the main characteristics of the cyberspace.

Computers in the cyberspace are mainly connected with WWW network, Electronic Data Interchange, multicast, P2P (peer to peer) and other solutions.

In this space the information transferring and decision making time is very short and is usually counted in split seconds. The basic management issue, which is managing with lacking resources, is usually dealt with new form, never used before:

- new market forms - electronic market,
- new organizational forms - virtual organizations,
- interactive portals with the active role of its users in its creation, development and exploitation,
- possibility to use the global knowledge banks such as the European Library,
- virtual participation in different endeavors such as possibility to join New Year's Eve party in Sydney (2008/2009).

New situation in management development causes many unexpected effects to appear, such as creation of information society, globalization and democratization of our everyday life. On the other hand there are many threats connected with this situation. One needs to be prepared for losses and dealing with types of crime never before present, such as cyber terror, financial and bank frauds, black PR.

The development of management theories is presented in the Figure 1. This Figure illustrates the tendencies that appear in management practice, which indicate that certain theories and concepts are constantly developing. Many new theories are created on the basis of the old ones, which are the main source of inspiration.

3. Knowledge as the basic element of the new management theory functioning

Information and knowledge as well as procedures on its gathering, processing and adjusting to the needs of the final users, are the basic elements of the new theory. Modern organization is functioning in global economy, which is known for the fierce competitive rivalry in the market. Many mergers and alliances are usually of strategic nature and are aimed at strengthening the market position of an enterprise. This situation is present both in local and global market. Not only does the enterprise need data and information to realize set goals and mission, but also content related know-

ledge. Such knowledge is gathered from the employees as well as gained from the closer and farther environment of the enterprise. In his characterization of management sciences development Tiwana [41] is giving the following definition of the XXI century: knowledge management, intellectual capital, Integrated Informational Systems (such as ERP I /II, CIM), culture favoring knowledge transfer.

Development of knowledge and information management related sciences is possible only if it is supported with a proper management infrastructure. This infrastructure consists of such IT elements as: hardware, software, information transferring networks such as Internet, intranet and extranet. While developing this hypothesis one can claim that IT application, especially the creation of integrated information systems [SWD, SE, BI, ERP], together with tolls like: databases, data stores, knowledge and model bases, allows the practical use of knowledge management. Relation between knowledge management and an information system is presented in the Figure 2.

According to McDermott [6] IT technology is inspiring for knowledge management. The only factor that assures proper enterprise development strategy is the use of computers. It is said that the computer infrastructure is the basis for knowledge management. Grudzewski and Hejduk [12] in their analysis of the technology development impact on the enterprise of the future come to a conclusion that both gigantic Boeing manufacturing process and the activities of Bill Gates would not be possible without the use of modern management methods, high organizational culture, use of innovative technologies and modern IT. The authors claim, on the basis of theoretical deliberations on management theory those upcoming years will be the beginning of the age of information and data processing.

It is assumed that knowledge is the immaterial organizational resource connected with human activities, which can be the basis of competitive advantage of the enterprise. Knowledge is related to the possessed intellectual capital, which is: data, information, procedures as well as experience and education of the users. Knowledge is strongly connected with the following factors: culture, ethics, intuition, working conditions, management style. The latter has a major impact on the effectiveness and efficiency of knowledge management system what has an influence on the competitive position of a company.

From the organizational point of view the main issue is not the knowledge itself but its practical applications, what was emphasized by Wawrzyniak [45]. One can assume that whether a resource is a data, informational or knowledge resource is determined through the practical use of it.

Sometimes it is assumed that knowledge is the type of immaterial resource which does not become obsolete, is not consumed and does not worn out while made accessible or popularized. This view is correct only when taking the physical data carrier into consideration. Knowledge recorded on data carriers or spoken out is not wearing out. However, in most cases, during the popularization process it loses its value and unique nature. It is similar to the situation of changing working conditions. Every person that is professionally dealing with knowledge gathering is encountering this problem.

This situation is a result of a simple dependence that a knowledge possessed by an individual has far greater value that the same knowledge possessed by many people. It is important to point out that knowledge that is not used becomes useless.

Toffler [43] names the following features that distinguish knowledge from the traditional resources:

1. Domination – knowledge is superior in relation to other resources. It is the success factor of an enterprise. Remaining resources are only supplementary to knowledge. Market future and competitive advantage relies on proper and effective knowledge management.
2. Inexhaustibility – use of knowledge does not decrease the intellectual resources of the company. The use of knowledge models a new way of use of manufacturing resources. Experts claim that when the employees make the knowledge available, knowledge resources of the organization increase through gathering of new elements possessed in the knowledge transferring process. Concepts popular in traditional economy such as e.g. depreciation are not applicable in knowledge management.
3. Simultaneousness – in knowledge management it is a situation when the same knowledge can be simultaneously used by different people in different places.
4. Nonlinearity – This is defined as a lack of proper measurements of relations between the amount of knowledge and economical effect. Having large

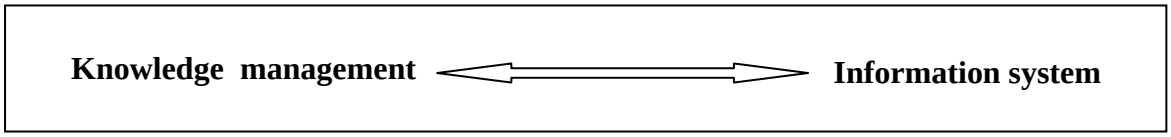

Figure 2. Relation between knowledge management and information systems *(source: [6])*

amounts of knowledge does not necessarily mean that one enterprise has a competitive advantage over the other. At the same time a fraction of knowledge can cause a chain reaction and lead to gaining of market competitive advantage and other significant effects (this is usually defined as the "butterfly effect"). Nonlinearity is the impossibility to predict the effects of knowledge possession and the fact that the same knowledge can bring significant development in one organization and bring no effect at all in another. It leads to a conclusion that the chain: knowledge – high management competences – decisions, needs to be taken into consideration.

Immateriality is another significant feature of knowledge what was pointed out by Jarugowa and Strojny [16]. Knowledge cannot be simply counted and shown as an asset in accounting. It is a strange kind of resource that even if it is sold one is still in a possession of it. Franchising can be one of such examples – the more licenses are sold the bigger is the value of a mother company. Knowledge development and building up core competences requires time what means that gaining competitive advantage based on knowledge management can be hard do recognize [10].

Knowledge has the following features (see [30]):

- it is created in many different circumstances and can become a product, which can later be sold,
- it is not unambiguous – it can be interpreted in different ways by different people,
- it is dynamic and quickly becomes obsolete,
- it materializes through products and services,
- in can be structured in different types of IT systems (especially in knowledge bases).

Knowledge classification, necessary for enterprise management, according to its adjustment and possibility of presentation with IT technology is crucial for this elaboration. Two approaches, with suitable simplification born in mind, can be distinguished for knowledge resources creation: Western and Japanese. One can also encounter a mixed Scandinavian approach, which is basing on enterprise's intellectual capital research and evaluation – so called estimation of business value.

Western approach is supporting open knowledge. This approach is represented by Simon and Drucker and in this approach knowledge is equal to database record, chemical formula or a set of regulations. For example Arthur Andersen Consulting [32] based its functioning on the creation of formalized knowledge creation procedures. Does the application and sustaining of this rule led to the bankruptcy of the company is another issue. It seems that an efficient functioning of an enterprise requires also the Japanese approach. Application of this approach is extremely difficult, especially for people dealing with recording of knowledge resources.

Japanese approach is presented e.g. by Nonaka and Takeuchi [33], who claim that formalized knowledge, expressed in words and numbers, is only the tip of an iceberg. Japanese corporations take the "hidden knowledge" (tactic knowledge) approach, which means that knowledge is not directly visible or directly expressed. The knowledge that creates business value is highly individual and difficult to formalize. This is the reason why this knowledge is difficult to share and transfer to other employees. Such kind of knowledge includes intuition, gut-feeling, corporate culture thus everything that cannot be expressed in the artifacts of the enterprise. Moreover the knowledge is deeply hidden both in individual activities and experience as well as ideals, values and emotions.

Open knowledge is relatively easy to record with Information Technology tools. Application of such tools as databases and knowledge bases allow to record open knowledge. Knowledge is recorded through the use of different models such as PERT/CPM schedules, decision making tables, mental maps, goal trees, UML language and other models. Recording hidden knowledge is more difficult due to the fact that it usually exists in the mind of people.

K. Perechuda, during NTIE conference stated that „knowledge is hidden id us, therefore it cannot be transferred" (Morsko – NTIE 2004 Conference).

Different relations occur between the management system and the type of knowledge present in an organization – see Table 1.

Figure 3. Relations between data, information and knowledge *(source: [44], p. 349)*

Table 1 presents the type of knowledge that is more useful according to implemented management system: centralized or decentralized.

Table 1. Relations between management style and knowledge type *(source: self study)*

Type	**Centralized management system**	**Decentralized management system**
Open Knowledge	Crucial for the decision making process	Supporting the decision making process
Hidden knowledge	Supporting the decision making process	Crucial for the decision making process

Therefore according to the main subject of the article, centralized management system is easier in terms of IT application. Demand for knowledge especially addresses the open knowledge, which, with the use of modern IT tools, is relatively easy to record in the knowledge base.

For the purpose of this article a different kind of division of basic kinds of knowledge is necessary. Presented proposition is a modification of Jehari window model, which is used for interpersonal communication analysis. Adaptation of this model for the classification of basic knowledge types is presented in the Table 2.

Table 2. Classification of basic knowledge types *(source: self study based on [11] and [39])*

Open knowledge, accessible for the organization, employees and the external environment.	"Blind" knowledge, inaccessible for the organization and its employees but accessible for the external environment.
Hidden knowledge, accessible for the employees but inaccessible from the company's external environment.	Unknown knowledge, inaccessible for the organization, employees and the external environment.

4. Information and knowledge management determinants

Recording of open, hidden or "blind" knowledge is not a problem for modern Information Technology. The only condition for the recording is for the knowledge to come into existence. However modern IT solutions, such as the use of semantic and related agenda systems, aim at possibility of recording of unknown knowledge. This is favored by the development in IT tools responsible for data gathering. It relates to shallow and deep gathering of information from the Internet (for more details please see the monograph by Abramowicz [1]).

When speaking about the new management theory it is crucial to point out the features, which distinguish it from theoretical and practical solutions of traditional management theories. **The main difference between classical theories and the new approach is that the new theory is based on specific resources of knowledge and information, which were never explored before.** Knowledge is gathered from information what is presented in the Fig. 2. What is knowledge and what is its function in the management process. The answer to this question is presented in the previous definition of knowledge as a basic element of functioning for the new management theory. It is necessary to emphasize that even seemingly irrelevant piece of knowledge can lead to unexpected and great benefits inversely proportional to the resources used to gain it. World is constantly changing, business processes are subjected to transformation and only the possession of information and knowledge resources assure the possibility to monitor the change processes and make proper corrective and development decisions.

Features that are the result of the specific character of the information resource have both micro and macro character.

Main macro determinants include:

- creation of information society,
- creation of new electronic forms of global organizations and the global market, which through trans-

formation replace traditional structures and cause cultural changes in management systems – knowledge based intercultural management,
- modification of old organizational structures in the economy and administration,
- cultural changes in management systems.

Main micro determinants include:
- direct knowledge and data transferring system, which eliminates intermediaries through creation of hubs allows decentralization and democratization of management, elimination classical hierarchical organizational structures,
- creation of flexible organizational forms, so called virtual teams, which are directed at knowledge sharing in task realization, independently of the geographical location of team members,
- different from the traditional approach formulation of basic elements of economic calculations such as: investment expenses, boundary production costs and relation of these costs to the scale of production,
- use of such knowledge management methods and techniques, including expert systems, which allow fast decision-making in constantly changing environment.

Listed features are the most crucial ones but are they adequate and sufficient to speak of new management theory? In this case answers may vary. However, it is not possible to discuss all related issues in one article or even a series of articles.

The assumption is that the article points out the problem and starts a discussion on the subject of the development of the new science area. This discussion should pay special attention to the virtualization process realized through IT and the new type of organizations created on the basis of these processes. According to Hammer and Champy [15] this process leads to revolutionary changes both in the theory and practice of management science. Current theory is not always suitable for new conditions and its practical usability is limited. Virtualization process includes also advantages brought by virtual technology, which will be described in the following part of the article.

5. Role of IT technology and tools in the creation of the new theory

IT technology is supporting modern management infrastructure, which is providing information and knowledge to its users. The role of Internet can be compared to the one played by one the first computers ENIAC, which was the basis for the creation of quantitative with system approach theory. It is a similar situation because technical resources again allowed reaching a new quality in management. The most significant elements of these organizations are the global computer networks, large and dispersed databases, data warehouses and knowledge bases, which function independently of existing country boundaries. The World Trade Forum discussed in 1997 the topic of “Building of networking societies”. Even though over ten years passes since that event, issues and problems signaled there are still significant and important (see [5]). Creation of global networks and knowledge bases is a chance of development for different organizational forms as well a chance for individual society members Relationships of particular elements of virtual organization are for example: Internet global network, WAN networks or urban MAN networks.

Computer network is a cooperation channel between virtual and real elements of the organization in the global market. Usually computer system access and proper use of it becomes the success factor. For example, virtual technology changes the manner of business contact and negotiation between the transaction participants. It is different from traditional contact between the purchaser and the salesman and is realized via MRP/ERP system or with CRM (Consumer Relation Management).

According to E. Tiwana ([42], p. 34-35), while analyzing relations between knowledge management and CRM systems, “While processes are becoming more and more dependent on knowledge—transaction costs are decreasing and current needs are deciding about new relations”. The author also points out that a major integration of customer based knowledge leads to a situation where “Enterprises which are able to change the knowledge in the minds of its employees and customers into practical possibilities and relations, will become leaders”.

Functioning communicational systems have the greatest influence on the realized uses of virtual technology. Traditional systems of communication are often replaced with virtual technology or modified with the use of it. Contrary to still commonly used traditional systems; new communication systems function in the cyberspace. One of the main features of the cyberspace is that the place, time and way of transaction realization are not relevant. Examples of appliance of virtual tech-

nology listed in the table can be defined as e-commerce. E-commerce subjects, procedures and information is using infrastructure basing on teleinformational networks. Communication with the use of such networks is a necessary condition or the existence of e-commerce.

E-commerce can be presented as a building (Fig. 4), of which:

- „foundation" is the IT that consist of: Electronic Data Interchange, modern programming languages such as Java and HTML, databases, knowledge and model bases, data storages as well as computer network of different types (global, local, urban or municipal),
- „walls (pillars)" are people, organization, procedures, corporate culture, economic and social policy,
- „roof" consists of two particular applications in banking, trade, industry and marketing.

When considering e-commerce in terms of communicational system it can be defined as a system that allows provision of information, production, services, financial resources with the use of technical resources such as computer networks and other electronic data interchange resources. Therefore, according to application we deal with different properties of the communicational system. Communication system used in business appliances is characterized extreme pace and directness of realization (elimination of intermediaries and activities).

E-commerce is the part of market, which is functioning due to Information Technology. This technology allows the realization of material, informational and financial flows.

From the business perspective e-commerce allows the use of proper IT technology that allows automatic business transactions. Main benefits are: speed of reaction, reduction of errors and mistakes number, possibility of transactions between market participants, who normally would not perform it.

Communication system functioning in e-commerce is based in interactions and relations network. This has both advantages and disadvantages. Limitations occurring in everyday life like building or street renovation or seeking of a place to file in the complaint will not affect the functioning.

Virtual technology contributed to the creation of the greatest market in the history of our civilization –

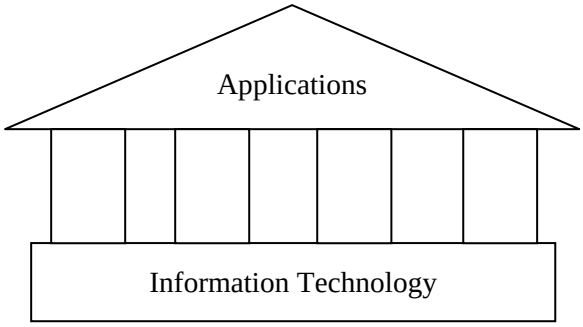

Figure 4. E-commerce structure *(source: self study)*

the e-market. This technology is used to create virtual organizations as well as providing products and services, real or virtual. It uses tools that are different than in classic approach, such as: virtual machines, modeling, and simulation.

Virtual technology can be considered in two aspects:

- technology used for the creation of virtual products,
- tools, which allow replacing traditional tools with more efficient and effective ones.

It also means the entity of knowledge that concerns creation of virtual product such as: virtual organization, virtual education, virtual teams and virtual reality. In order to create such products, ITC knowledge is necessary, especially about communication platforms, multimedia systems, portals. It is also a kind of information technology, which allows the influence on real environment controlled by the computer or computer emulated. The latter aspect leads to computer simulation that replaces traditional reality with virtual reality. As a result we can efficiently research a problem without taking personal risk (thermo-nuclear reactions, radioactive pollution and other subjects like stock market simulation without the risk of losing financial assets).

Modeling allows broadening the possibilities of our activities in the changing environment and to become more competitive as well as gain new experience without the necessity of functioning in the real world. Table 3 collects selected possibilities given by virtual technology. Presented table can be considerably extended, especially in the areas like medicine, transport, agriculture.

The success of particular people or organizations often depends on the access and ability to effectively use the virtual technology. For example, virtual technology changes the manner of business contact and negotiation between the transaction participants. It is different from

Table 3. Examples of virtual technology appliance *(source: self study)*

Area of activity / Object of activity	Business	Administration	Education	Culture
Human	Electronic banking, Management cockpit	Tax return	E-learning	Movie selection
Organization	Virtual team, Virtual organization	Participation in offer bidding	Virtual University, E-learning	Virtual museums and art galleries
Organization system	E-market	E-government	Virtual, global librarian collection	Virtual, global museum collection

traditional contact between the purchaser and the salesman, realized via MRP/ERP system, CRM (Consumer Relation Management) or with the BI (Business Intelligence)

6. Information and knowledge management – development perspectives

Near future will reveal whether the new information and knowledge management theory will be implemented into professional activities. Are there going to be created organizations which will require changes in the existing, traditional theories and adapting to changing market situation?

Virtual technologies are going to be the experimental ground due to the use of Information Technology. Issues of e-commerce and e-business will require the use of new management methods. Therefore the development of this new management theory depends on the development of IT tools. Never before has there been such a great stress laid on resources like information and knowledge. Globalization processes forced effective management to be based on information and knowledge from different areas of human activity and his or hers environment.

Controlling complex processes triggers demand for current information and knowledge. Knowledge features such as dominance, inexhaustibility, simultaneousness, nonlinearity, immateriality, are efficient with the use of modern management methods. In many kinds of science the knowledge passed to students in the beginning of the semester becomes obsolete in the end of it.

Does the issue end here? Wisdom management becomes a current topic of discussions. The main problem of this concept is a clear definition of wisdom and its relation with knowledge.

Modern World can be presented as a large system. Information system is a sub-element of the World system. Subsystem plays the role of a nervous system, which provides different informational signals to all objects that are creating it.

According to G. Morgan ([31], p. 399) „Organizations are simultaneously many different things" and further (p. 418) that they should be analyzed as „decision making and communication system". To analyze this statement one needs broad research on information that is describing the organization as well as the one describing its environment.

Currently large fully accessible knowledge bases are built in many countries individually and in cooperation. European Union realizes the "E-Europe Strategy" as one of the virtual technology initiatives. This especially concerns productivity increase with the provision of knowledge about new markets and public services. It stops being an egalitarian good and starts to be an accessible good. In the knowledge bases it is stored as a hidden knowledge and as an open knowledge. Access to the gathered knowledge requires proper preparation of the users. Its basis is the realization of the statements: "My knowledge base is where my laptop is and I can use it whenever I need it" and "I am using the necessary knowledge in suitable time".

Presented article describes selected issues of presented new management theory. Presented aspects, even though being only a small part of all related issues, are crucial and sufficient to support presented hypothesis. Theoretical basis of the new school were already defined by other authors. It is important to mention the works of famous cybernetics like Wiener [46], Beer [3] or Ashby [2]. These works have drawn the attention to the fact that everything can be analyzed in the aspect of information. These researchers did not have proper tools to verify their hypothesis. Currently the situation

has changed – we have suitable tools and methods. Management theory is developing, what allows to move from management in stable conditions to dynamic management in constantly changing environment.

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FORECASTING THE EFFECTS OF INVESTMENTS IN KNOWLEDGE-WORKERS IN THE SME SECTOR, USING THE GMDH METHOD

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Abstract: The enterprises functioning in market economy have to implement changes in systems of organization and management that they use. In economy practice making a decision in enterprise is conditioned by competitors' action, changing factors of environments, e.g. technical progress and results of the research works. Added value for SME can be determine as knowledge, employees' skills and abilities, social relation, know-how, and particularly effective investing in intellectual capital. The enterprises which invest in knowledge and systems of work are achieved competitive advantage, because of their workers' readiness to learning and qualifying themselves and also thanks to effective information and communication transfers. In this paper we allowed to respond to the following question: whether a given algorithm that enables the characteristics of the knowledge-workers and the expected results of expenditures on the intellectual capital (potential benefits from investing in the knowledge-workers) binding? This paper presents prediction effects of investments in knowledge-workers in the SME sector when using the neural systems GMDH basing on the Ivachnienko algorithm.

Key words: Intellectual capital in SME, GMDH method, investing in intellectual capital.

1. Introduction

Currently, the advantage of a company in the SME sector is determined by effectiveness and the extent of the knowledge-workers' involvement. The role of human capital management consists in striving to increase the share of immaterial resources (at the costs of the material ones) in the generated products, services, and the total market value of an organization [10]. It is an important part of the intellectual capital of an organization, as it influences the development of its other elements, i.e.: the structural capital and the customers' capital [2]. The subject literature includes various definitions of the intellectual capital. „Intellectual capital means the possessed knowledge, experience, organizational technology, relations with customers, and professional skills which provide [...] competitive advantage on the market" [5]. "It is a knowledge which can be turned into value" [8].

Building the company's intellectual capital, the employees must cooperate in creation of the company's value. In this context, the employees should be convinced that they work in a strategic partnership and generate benefits in the company. Such employees are distinguished by specific traits (intelligence, involvement, energy, positive attitude, reliability, honesty), ability to learn (receptivity of the mind, imagination, analytical thinking), and motivation for sharing the information and knowledge [15].

On the basis of the definitions, it can be assumed that a knowledge-worker is distinguished by:

- creativity (C),
- knowledge (K),
- qualifications (Q),
- reliability (R),
- skills (S),
- involvement (I),
- honesty (H).

In the SME sector, the knowledge-employees can be evaluated according to the aforementioned characteristics:

$$Kw = \{C, K, Q, R, S, I, H\} = \{C = 1,\ldots, n; K = 1,\ldots, 5; Q = 1,\ldots, 5; R = 1,\ldots, n; S = 1,\ldots, p; I = 1,\ldots, n; H = 1,\ldots, p\},$$

where each trait of an employee is precisely defined, and has an ascribed value:

- C – creativity – ability to generate new, innovative ideas (index: number of ideas (new solutions, created by the employee during a year),
- K – knowledge – proper processing and usage of information (index: results of a specialist test of the given employee, the test is constructed depending on the employee's profile, graded 1 to 5: 1-poor result, 5-the best result),
- Q – qualifications - education and professional experience (index: graduating from studies, post-graduate education, courses, trainings – secondary education: 1, higher education: 2, additional specialist courses: 3, post-graduate studies: 4, MBA studies: 5),
- R – reliability – preciseness of the completed tasks (index: number of complaints from the customers during a year,
- S – skills – quality the completed tasks (index: work productivity),
- I – involvement – creating productive relations in a company (index: number of new customers gained during a year),
- H – honesty – completing tasks based on trust (index: number of employees' meetings in which the employee participated and given the new ideas to the number of all the meetings during a year).

For a company, investing in the knowledge-workers comes down to organizing trainings for the employees (the second chapter of this article presents the remaining factors of intellectual capital development). Treating the training as an investment results in expectations of reimbursement of the incurred expenditures in a specific time. Yet, assessing profitability of an investment in the intellectual capital requires the so-called soft categories, e.g. the company's organizational culture. A method, which on the one hand would allow for demonstration of relationship between the knowledge-workers' characteristics, and company's benefits, and on the other would allow for estimation of the potential results of expenditures incurred on the intellectual capital, is sought.

The following research thesis has been put forward: *There is a very specific relationship between the characteristics of the knowledge - workers, and the expected results of expenditures on the intellectual capital (potential benefits from investing in the knowledge-workers). In other words, investing in the intellectual capital is profitable, if the value of the potential benefits function B(Kw) is acceptable for the management of the SME sector company.*

Furthermore, the following research problem has been formulated: *Important potential benefits generated by the intellectual capital are distinguished in the SME sector company. Is there a method allowing to estimate the return on an investment in the intellectual capital, in the category of gaining the expected benefits?*

The second charter of the article presents a conception of knowledge-workers management in the SME. Factors influencing the development of the intellectual capital in the SME were defined, and the expected benefits from expenditures incurred on the intellectual capital were distinguished. Methods of evaluating profitability of investments in the intellectual capital, known from the subject literature, were demonstrated. The need of applying econometrical methods to solve the stated research problem was emphasized.

The third chapter contains characteristics of the GMDH as a method allowing to define the potential return on investment in the intellectual capital. Current examples of applying this method were presented.

The fourth charter presents the process of forecasting the return on investment in the intellectual capital, in the aspect of gaining expected benefits by the company management.

The summary presents directions of further works.

2. Managing intellectual capital in SMEs

The process of managing intellectual capital should consist of two stages: identifying and measuring. Literature distinguishes qualitative measures (e.g. Danish project of IC measurement, 'Scandia' navigator, intangible assets monitor, IC model – TM Rating, VCSTM, balanced result sheet, report by Saratoga Institute) and methods of valuating intellectual capital (e.g. MV/ MB, q-Tobin, CIV, KCE, VAICTM, economic added value, IAV model, Strassmann's method, IAMVTM, technology broker). Attempts are made continuously to find methods for measuring intellectual capital and still there is no one recognised method enabling to build an intellectual capital reporting system. The difficulty is that the majority of concepts are prepared for specific companies, in other words such measuring methods are tailor made and their general application is not possible. [4, 5, 7, 9, 12].

Table 1. Analysis of methods of valuating intellectual capital
(source: self study on the basis of [4, 9, 15])

Methods of valuating intellectual capital	**Advantages**	**Weakness**
Ross's method - indicators in two classes: human capital, structural capital	Value of intellectual capital's indicators	Subjective choice of intellectual capital's indicators
Danish project of IC measurement - indicators in 4 classes: human capital, structural capital, organization technology, relations with clients	Dynamic matrix of intellectual capital's indicators	Insufficiently number of intellectual capital's indicators
Scandia navigator – measuring intellectual capital based on analysis of 5 areas: client, finance, processes, personnel, organization's development)	Monitoring of organization's productivity.	Subjective choice of intellectual capital's indicators.
IC – Rating^{TM} - measuring intellectual capital based on 4 areas: business policy, human capital, relation's capital	Intellectual capital as organization's added value	Subjective choice of intellectual capital's indicators.
Intangible assets monitor - intellectual capital's indicators in 3. areas: inner and external structure and competence. In the each area in 4. classes: increase, regeneration, productivity, stability.	Controlling in the area: intellectual capital	Subjective choice of intellectual capital indicators
Balance Scorecard – indicators in 4 areas: finance, client, inner's processes and learning process.	Logic matrix of intellectual capital indicators	Static matrix of intellectual capital indicators
VCS^{TM} - indicators in 3 phases: design of new product, analysis of technological processes, initiation of product in the market.	Research of main enterprises information's needs.	External reports
Value discoverer – 3 stages: 1) identification of competence and of intangible assets; 2) valuating of weakness and advantages of intangible assets; 3) resource allocation.	Indentifying of main competences.	Subjective choice of intellectual capital indicators.
Report by Saratoga Institute – indicators in the 6 area of intellectual capital: organization's productivity, human resource structure, salary, added welfare, dismissal, training	Matrix of a few area of managing intellectual capital.	Not for SMEs
MV/MB – relation between the market and account value, (if the relations is more than 1, that the intellectual capital exists.	Simply calculation	Over - simplification
Q – Tonbina - relation between market value and intangible assets value (if more than 1 and „q" competition enterprises, that the profit of intellectual capital exists.	Simply calculation	Over - simplification
CIV – value of „current prizes"	Simply calculation	Average value of indicators
VAIC^{TM} (KCE) – value of intellectual capital	Correlation between profit of intellectual capital and profit of organization's activity	Profit of material assets , finance assets and intangible assets

Methods of valuating intellectual capital	Advantages	Weakness
Economic added value	Correlation between profit of intellectual capital and profit of organization's activity	Complicated model
IAV – the organization's value based on innovation and business assets	Meaning of innovation and business assets in added value creating.	Profit of material assets , finance assets and intangible assets
Strassmann's method - knowledge's base (market value and cost of knowledge's capital)	Exact date's base	Over - simplification
IAMV^{TM} – definition of market value as the account and market value.	Indentifying of main intellectual capital's parameters	Subjective definition of the account and market value.
Technology broker – intellectual capital value is based on indicators in 4.classes: human capital, structural capital, organization technology, relations with clients .	Treating intellectual capital as product creating.	Qualities results

The following is a presentation of vices and virtues of the selected qualitative measures and methods of the intellectual capital evaluation, based on the subject literature [4, 9, 15], table 1.

As a result of the completed comparative analysis of the measurement models and evaluation of the intellectual capital (table 1), a need to create a method of forecasting the effects of investing in the company's employees was noticed. In the SME sector company, there is a database, containing precisely defined values of the knowledge-workers' traits, and the specific values of the expected SME benefits from investing in the human capital are defined. A solution allowing to make a strategic decision in a company, regarding investments in creation and development of the human capital, is sought. The following conception of analysing the profitability of a strategic decision in the personal function realization process was adapted.

Treating the deliberations on the profitability of strategic decisions in a company in the category of knowledge-workers development, and simultaneous gain of competitive advantage, the human capital development factors were defined (table 2).

Assuming, that specific expenditures on the knowledge-workers must be incurred, benefits (specific values of the determined indexes) from the outlays incurred in the company should be expected.

Benefits at the level of organization in the SME sector company were defined (on the basis of the subject literature and the author's own research).

- Return on Assets (ROA) - profit net / assets,
- Return on Equity (ROE) - profit net / equity,
- Return on Sales (ROS) - profit net / return,
- share working capital in assets - working capital/assets, where working capital = current assets - short-term liabilities,
- number of paten (license),
- number of innovative project.

Table 2. Knowledge-workers development factors, *(source: self study on the basis of [10])*

Knowledge-workers development factors	Detailed description
Trainings	Set of purposeful, systematic actions, aimed at extending and deepening of specific elements of the human capital, and at equipping it with new elements, useful now, or in the future, for the employees of a given company
Reorganization of competences	Extending the scope of decision-making and/or enriching the work content
Organizational culture	Set of values, models, and convictions which is perceived by the company employees
Balance between career and private life	Programmes supporting flexible working time (e.g. annual work settlement, compressed working week, dispersed work)

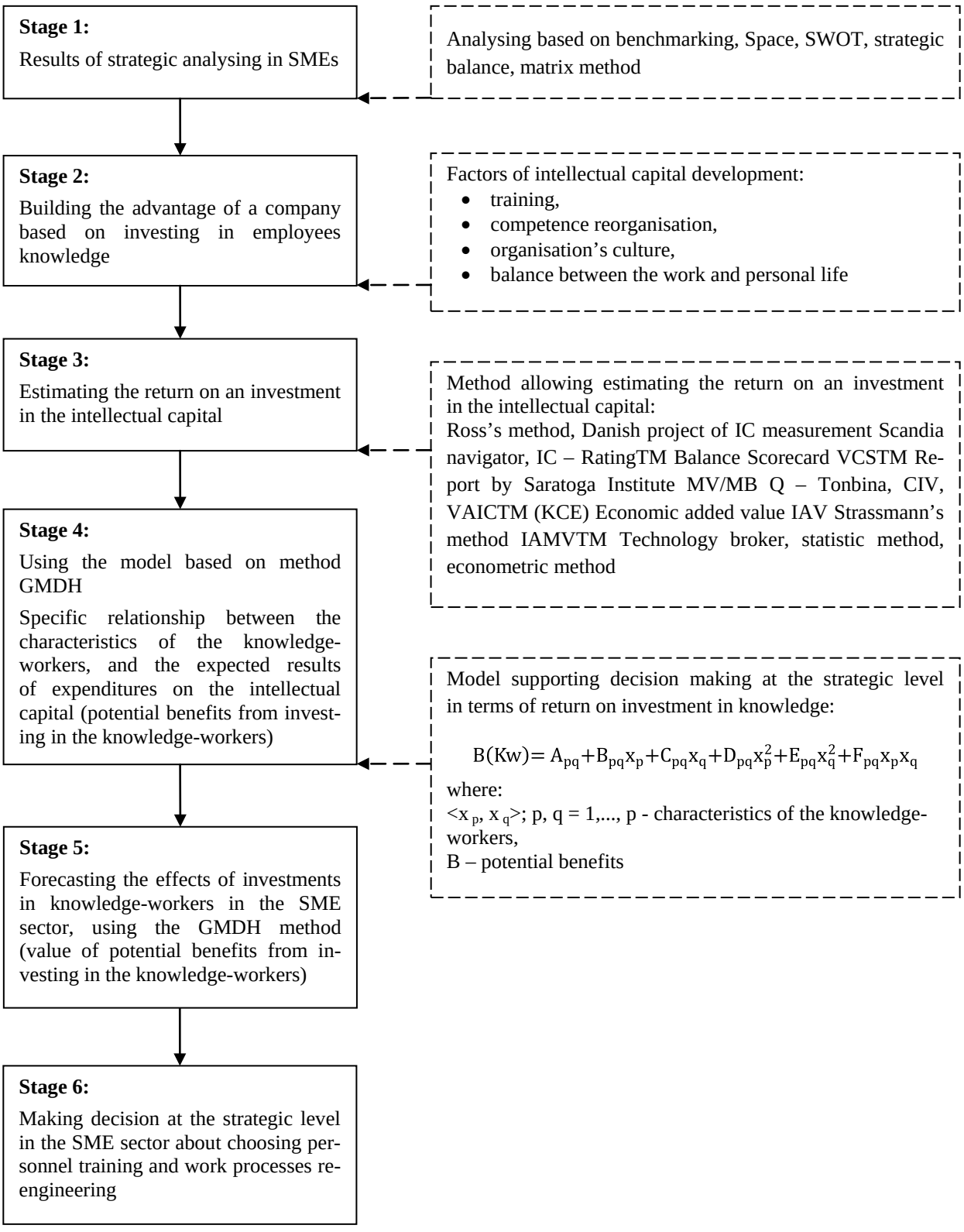

Figure 1. Conception of analysing the profitability of a strategic decision in terms of return on investment in knowledge *(source: self study)*

An attempt to define potential company benefits from investments in the human capital was made. The Group Method of Data Handling (GMDH) was adopted as a mean allowing for precise description of relationships between the input and output data in the given time horizon, guaranteeing independence from the subjective theoretical knowledge, and minimization of modeling errors. The set of knowledge-workers' traits' values and benefits in the SME sector company are considered the input data. It is suggested to use the GMDH algorithm as a genetic algorithm, with the following interpretation:

- the chromosome is a single multinomial as follows $A+Bx+Cy+Dx^2+Ey^2+Fxy$,
- the population is a set of multinomial examined in the current iteration,
- the evaluation (adjustment) function is the regularity criterion.

Setting up the structure for the model supporting decision making at the strategic level in terms of return on investment in knowledge with the parameter identification model of developed structure involves a great deal of calculation, especially in the case of the object high initial input number. The complication that the calculation of the algorithm involves was greatly reduced by implementing GMDH method. This method came into existence as a result of combination of LS Gauss optimization theory and Gödel logical openness theory, which makes a completion of the Iwachnienko hierarchical synthesis procedure.

Chapter three presents examples of applying the GMDH algorithm.

3. Practical examples of applying the GDMH algorithm

The basic assumption of the algorithm GMDH was to eliminate a deductive approach based on engineers and experts' knowledge. Another important element was the idea of polynomial evolution from its elementary structure to optimised one through selecting various combinations of simple partial models. In the majority of cased these are polynomials second degree with two variables. According to the concept, considering that at each iteration arguments supporting the elementary model are polynomial functions consisting of previous iteration, the degree of the resulting polynomial doubles at each stage of the algorithm. Optimised values of fixed parameters are calculated using the least square method. Many applications, developed after publishing GMDH, confirmed it efficiency and broad application [6].

There is a number of examples of practical application of GMDH based on retrospective data groups:

- in Great Britain, in 1980-1990, with the use of GMDH, a 10 year forecast of inflationary changes was developed for the country (GMDH model for inflation changes was identical with actual inflation in Great Britain in 1990-2000),
- in 1990-2000, in the United States, the GMDH method was used to develop a forecast for the development of main economic growth factors,
- in 1990-2000, in Ukraine, the GMDH method was used to develop a 10 year normative forecast for macro-economic processes,
- GMDH was used to develop a forecast for changes in lake Baikal,
- in 1990-2000, in the United States, the GMDH method was used in diagnosing cancer,
- in the early 70s, Adptronics Inc., US, used GMDH in a device for controlling quality of materials used in aviation,
- ComputerLand, Wrocław, Poland, uses GMDH for detecting failure of digital and analogue electronic system power supply,
- boiler house and steam station in the sugar plant in Lublin, Poland, use GMDH to control precision of technological track elements. Research concerning method development and integration (including GMDH) and process diagnosing techniques (in particular regulation valves) in the sugar plant in Lublin was provided under the project of DAMADICS (DAMADICS (Development and Application of Methods for ActuatorDiagnosis in Industrial Control Systems) – funded from the 5th Framework Programme in 2000-2003, project coordinator: Prof. Ronald J. Patton, University of Hull, Great Britain).

Multilevel algorithm GMDH enables us to perform optimisation synthesis of the mathematical model for a given class of the regression function and it can be used in evaluation criteria choice as well as the estimation quality assessment. Both elements of the algorithm are defined arbitrarily by the developer that is why modeling must be proceeded by an initial identification phase which allows for both defining the choice and the class of the solutions in progress.

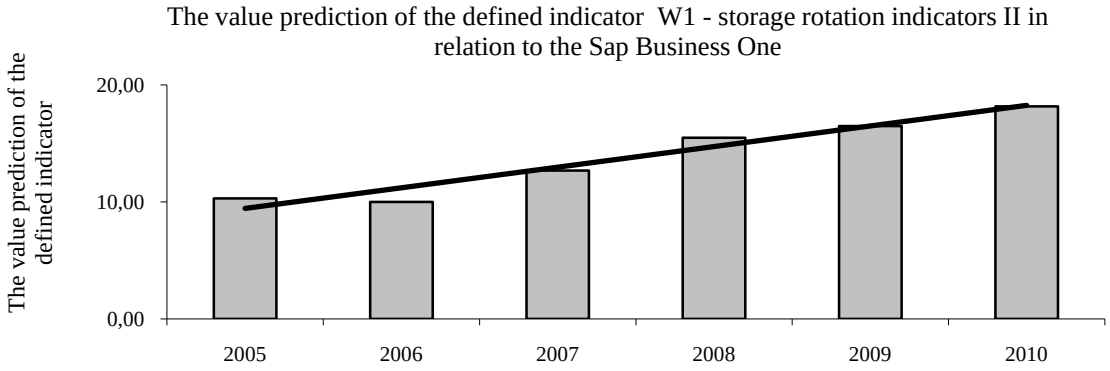

Figure 2. The value prediction of the defined indicator W1 – storage rotation indicators II in relation to the Sap Business One *(source: [13])*

Taking into account a specific kind of the objects in question, along with specific solution tasks supporting decision making at the strategic level in terms of return on investment in knowledge, it can be assumed that the regression function takes a form of two variables. A particle selection of integers is carried out with the regularity criteria.

Developing an object model with GMDH algorithm is carried out in steps. At every step the population regression integer is being generated. Because it was established that each of them is a function of two variables, the polynomials are assigned to every possible pairs of arguments. Their parameters are calculated using the method of the *least squares*, that is, using the sets of equation formulas. It can be concluded that GMDH procedure is conditioned by linear unit independence, which is a guarantee for the solution to be found [6].

Having generated the families of regressive polynomial, a selection takes place of those which approximately fit in interdependence under examination. Due to calculation assumptions, the restriction is assumed that the number of data (models) in a new population can not be higher than in the previous one.

For each population of particle solutions the lowest regularity criteria value is assigned (3). The steps 2 and 3 go through a loop until the value stops decreasing. It means that the optimal model was found which is a polynomial of regression for which the criteria has reached the lowest value.

There is an example of practical application of GMDH based on retrospective data groups [13, 14].

Let us consider the situation: the problem considered regards of chosen the ERP system objective and of assessment of effects of the system implementation. Enterprise resource planning (ERP) systems is an integrated software application used to support management and activities of organizations. Last years the strong competitions on the ERP market results with rapid development of the systems that today not only support resource planning needs but also integrate all departments and functions of a company [1, 3].

The best possible polynomial (decision model) in relation to the ERP: "Sap Business One" binding the selected indicators like W1 = labor efficiency indicator, W2 = storage rotation indicator II:

$$W(W_{1,}\, W_2) = 0{,}008\ W1 - 0{,}0002W2 + 0{,}00868W2^2$$

where:

W1 – storage rotation indicator II,

W2 – labor efficiency indicator.

The best possible polynomial (decision model) in relation to ERP: "the Comarch XL" binding the selected indicators like W1 = labor efficiency indicator, W2 = storage rotation indicator II:

$$W(W1,W2) = -46{,}58139 + 0{,}08647W1 + 1{,}07228W2 - 0{,}00007\ W1^2 - 0{,}03300\ W2^2 + 0{,}00099\ W1W2$$

where:

W1 – labor efficiency indicator,

W2 – storage rotation indicator II.

Decision model is contracted on the basis of the knowledge data base. It includes complex information about

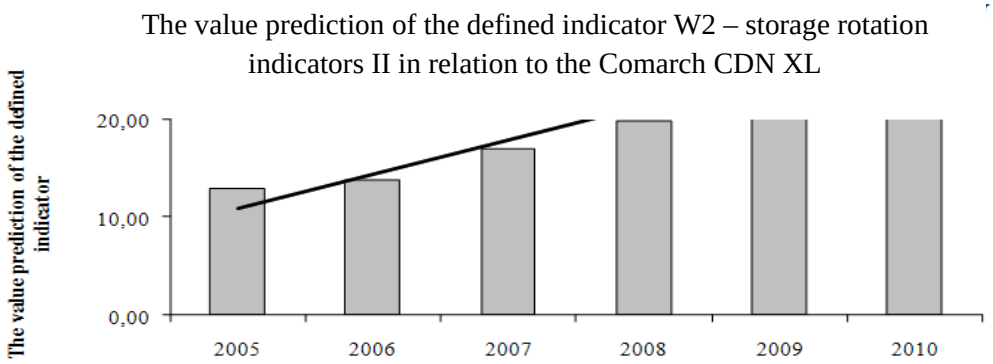

Figure 3. The value prediction of the defined indicator W2 - storage rotation indicators II, for Comarch CDN XL, (*source [13])*

all the processes, which could be observed while the date base was created, so both examples of successful and unsuccessful ERP system implementation are included. So, on the basis of the decision making model a forecast of a defined indicators value is introduced to the company A. As a result, the company A must make a decision as far as the purchase of the ERP system is concerned. This system is defined as Sap Business One, Comarch CDN XL, based on value forecasting.

So, on the basis of the data the function, which normalize the indicators W1, W2-assigned to the decision making model, is introduced. Consequently the normalize function for indicators W1, W2 (for ERP: "SAP Business One" and "Comarch XL") in decision models is shown in the Fig. 2. and in Fig. 3.

Sustainable increase can be observed in relation to the value of storage rotation indicator II. According to the definition the value storage rotation indicator II should increase with the development process of the company. Storage rotation indicator II refers to the interdependence where the increase in sale and the decrease in the storage volume (the direction of the value change of the parameters are among the others the indicators of the company development, thus the value of this indicator should also increase.

Based on the practical examples of applying the GDMH algorithm an attempt to define potential company benefits from investments in the human capital was made. The Group Method of Data Handling (GMDH) was adopted as a mean allowing for precise description of relationship between the characteristics of the knowledge-workers, and the expected results of expenditures on the intellectual capital (potential benefits from investing in the knowledge-workers).

4. Model supporting decision making at the strategic level in terms of return on investment in knowledge – case study

In accordance with the values of the characteristics of the knowledge-workers indicators and potential benefits from investing in the knowledge-workers here was constructed a decision model which contains the Group Method of Data Handling, which bounds this selected indicators. The data were collected in companies operating within the SME sector where an ERP system was applied.

In order to show the possibility of defining such a model let us consider the SME that deals with providing services for both organizations and individual customers (projects) and that has implemented ERP system (SME 1). The main areas of the SME 1 correspond to the following functions supporting: the sale, the supply, the orders scheduling, and the service. Company consists of 3 sell-departments.

The data (value of the characteristics of the knowledge-workers indicators and potential benefits from investing in the knowledge-workers) were collected from ERP system and from interview with management in enterprises.

Firstly, based on conception of supporting decision making at the strategic level in terms of return on investment in knowledge in the SME (Fig. 1) the stra-

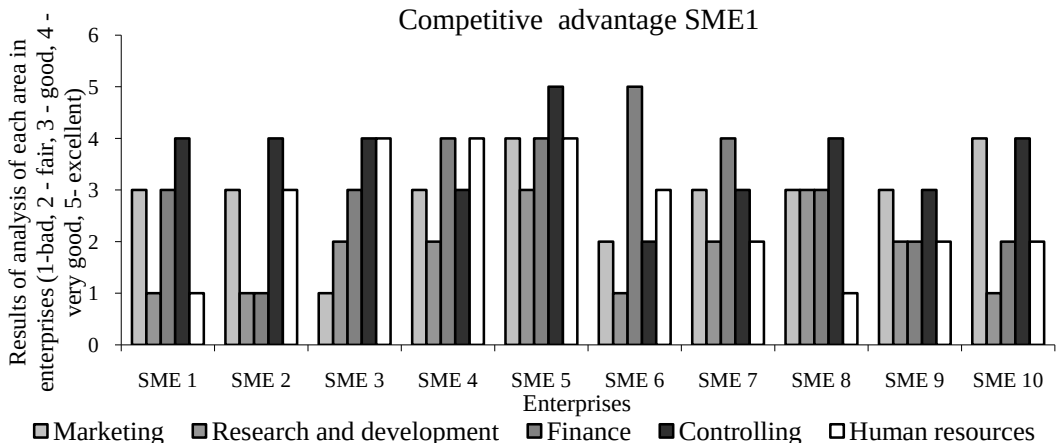

Figure 4. Results of strategic analysis of each area in enterprises – the strengths (*source: self study)*

tegic analisys was realized. Using of the strategic balance method, recommended directions for organization structure reform, were proposed for the company. The picture below (Fig. 4) shows results of analysis of the 10 enterprises SME sector in one region in Poland, which deals with providing services for both organizations and individual customers (projects).

The company (SME 1) is quite good in the area of marketing and controlling. As shown in the chart, there is a significant difference between answers about marketing and research and development. We can say that, in the field of human resource the company lacks competitive advantage. A decision for the investment in knowledge has to be made during the first step of building its competitive advantage in the areas of human resource. Staff is also a decisive factor for enhancing competitiveness. In the knowledge based economy, while trying to maintain their position in the market or access new markets, managers and employees need to improve their skills. This will help in being able to use innovative technologies that exist all over the world. Rapid changes force employees to put into practice the idea of life-long learning. Updating knowledge has become one of the most important civilization challenges of the information society [11].

The strategic analysis presented shows that there is negative result in the area of human resource. Also SMEs that are about to make decision concerning the investment in knowledge based on assessing the efficiency of human resource, tend to estimate the return on an investment in the intellectual capital, in the category of gaining the expected benefits.

The specific relationship between the characteristics of the knowledge-workers, and the expected results of expenditures on the intellectual capital (potential benefits from investing in the knowledge-workers) will be made on the results using GMDH method.

Secondly, a description will be provided on the findings of studies on the characteristics of the knowledge-workers (managers of 3 departments in SME 1) based on result of interview.

Characteristics of the knowledge-workers:

sell-manager 1

- C – creativity – ability to generate new, innovative ideas (index: number of ideas new solutions, created by the employee during a year): 3
- K – knowledge – proper processing and usage of information (index: results of a specialist test of the given employee, the test is constructed depending on the employee's profile, graded 1 to 5: 1-poor result, 5-the best result): 3
- Q – qualifications - education and professional experience (index: graduating from studies, post-graduate education, courses, trainings – secondary education: 1, higher education: 2, additional specialist courses: 3, post-graduate studies: 4, MBA studies: 5): 3

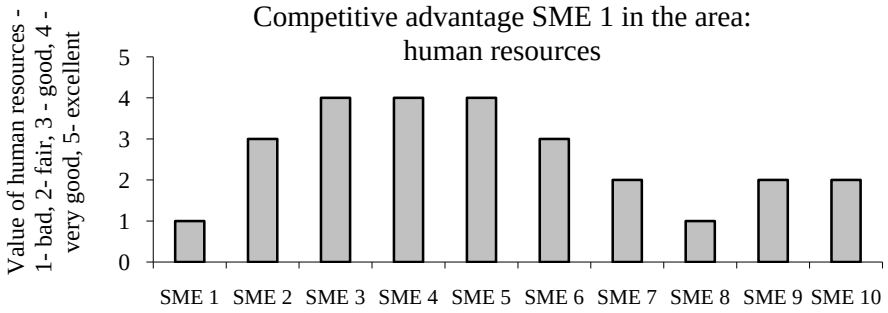

Figure 5. Results of strategic analysis of human resource area in enterprise – the strengths *(source: self study)*

- R – reliability – preciseness of the completed tasks (index: number of complaints from the customers during a year): 25
- S – skills – quality the completed tasks (index: work productivity): 11 391 536/ 2 411 294 = 4,72
- I – involvement – creating productive relations in a company (index: number of new customers gained during a year): 1 541
- H – honesty – completing tasks based on trust (index: number of employees' meetings in which the employee participated and given a new ideas to the number of all the meetings during a year): 8/13 = 0,61.

Characteristics of the knowledge-workers:

sell-manager 2

- C – creativity – ability to generate new, innovative ideas (index: number of ideas (new solutions, created by the employee during a year): 10
- K – knowledge – proper processing and usage of information (index: results of a specialist test of the given employee, the test is constructed depending on the employee's profile, graded 1 to 5: 1-poor result, 5-the best result): 3
- Q – qualifications - education and professional experience (index: graduating from studies, post-graduate education, courses, trainings – secondary education: 1, higher education: 2, additional specialist courses: 3, post-graduate studies: 4, MBA studies: 5): 2
- R – reliability – preciseness of the completed tasks (index: number of complaints from the customers during a year): 40
- S – skills – quality the completed tasks (index: work productivity): 16 323 553/ 1 444 700 = 11,29
- I – involvement – creating productive relations in a company (index: number of new customers gained during a year): 1 920
- H – honesty – completing tasks based on trust (index: number of employees' meetings in which the employee participated and given a new ideas to the number of all the meetings during a year): 7/13= 0,53.

Characteristics of the knowledge-workers:

sell-manager 3

- C – creativity – ability to generate new, innovative ideas (index: number of ideas, new solutions, created by the employee during a year): 1
- K – knowledge – proper processing and usage of information (index: results of a specialist test of the given employee, the test is constructed depending on the employee's profile, graded 1 to 5: 1-poor result, 5-the best result): 2
- Q – qualifications - education and professional experience (index: graduating from studies, post-graduate education, courses, trainings – secondary education: 1, higher education: 2, additional specialist courses: 3, post-graduate studies: 4, MBA studies: 5): 2
- R – reliability – preciseness of the completed tasks (index: number of complaints from the customers during a year): 10
- S – skills – quality the completed tasks (index: work productivity): 18889867/ 1606154 = 11,7
- I – involvement – creating productive relations in a company (index: number of new customers gained during a year): 2 137
- H – honesty – completing tasks based on trust (index: number of employees' meetings in which the employee participated and given a new ideas to the number of all the meetings during a year): 13/13 = 1.

Using of the data from ERP systems the indicators value of the potential benefits for each department are defined (Table 4).

SMEs that are about to make strategic decision concerning the organization of training for sell-managers tend to make a preevaluation of the efficiency of their very implementation (for example taking into consideration the level of the user's objectives realization). It was concluded that on the basis of the author's model supporting decision making at the strategic level in terms of return on investment in knowledge, the company will obtain the prediction of the defined indicators value the potential benefits before investment in training for sell-manager.

The method GMDH and the data base form company enable us to carry out an assessment of investment in knowledge. The precisely defined criteria of the potential benefits are ascribed form ERP system (Table 4), which allows us to define the potential values of these parameters before the investing in knowledge.

So, for the object from Table 3 of the output C,…, H and of one output y the matrix X is made:

$$X = \begin{bmatrix} C & K & Q & R & S & I & H \\ 2 & 3 & 3 & 25 & 4,72 & 1541 & 0,61 \\ 10 & 3 & 2 & 40 & 11,29 & 1920 & 0,53 \\ 1 & 2 & 2 & 10 & 11,7 & 2137 & 1 \end{bmatrix}$$

Columns 1,..., 7 represent independent variables C,…, H and vector y of the output value SWC = [0,56; 0,57; 0,64]^t. It is assumed that the columns of the matrix X are line independent.

In the first step, for each pair of independent variables the polynomials is created approximating the overall form:

$$y^* = A_{pq} + B_{pq}x_p + C_{pq}x_q + D_{pq}x_p^2 + E_{pq}x_q^2 + F_{pq}x_px_q$$

which is called Iwachienko polynomial (Table 5).

Altogether there are 42 polynomials. Each polynomial is being evaluated for all the observation from the X matrix. The values that are calculated are placed in separate supporting columns of Z matrix:

$$Z = \begin{bmatrix} Y^*_1 & Y^*_2 \ldots & Y^*_{42} \\ -1,6352 & 0,5193 \ldots & 0,6329 \\ -1,6248 & 0,5193 \ldots & 0,6608 \\ -0,8235 & 0,5893 \ldots & 0,7411 \end{bmatrix}$$

In the second step, for each column j = 1, 2,..., 42 of
Z matrix an equality criterion is assigned from the formula:

$$r_j^2 = \frac{\sum_{i=t+1}^{n}(y_i - z_{ij})^2}{\sum_{i=t+1}^{n} y_i^2}$$

where:
i – following observation of matrix X,
j = 1, 2, .., 42 matrix Z.

In the third step, the selection of the best polynomials takes place – of the least r factor value. If it is assumed that there is some stability in polynomial from Z matrix a selection of m column can be made, which are assigned to X matrix. In this way the output data become the input data for the next generation process.

So, in the following steps of the process we can come up with two polynomials with the least value of r_j^2 factor:

$$Y^*_{31} = Y^*_{34} = 0,8000 - 0,0700\,K - 0,0100\,Q$$

$$Y^*_{41} = 0,4553 + 0,0033\,S + 0,1461H$$

$$Y^*_{18} = 0,4228 + 0,2138\,H + 0,0034\,C,$$

where:
K – knowledge,
Q – qualifications,
C – creativity,
S – skills,
H – honesty.

Table 3. Results of research of characteristics of the knowledge-workers: sell-manager (*source: self study)*

	C	**K**	**Q**	**R**	**S**	**I**	**H**
M1	2	3	3	25	4,72	1541	0,61
M2	10	3	2	40	11,29	1920	0,53
M3	1	2	2	10	11,7	2 137	1

Table 4. Results of research of the potential benefits *(source: self study)*

	ROE	**ROA**	**ROS**	Share working capital in assets - SWC	Number of paten (license)	Number of innovative project
D1	4,84	2,18	0,80	0,56	0	0
D2	4,64	1,79	0,67	0,57	0	0
D3	5,33	1,74	0,67	0,64	0	1

Table 5. The polynomials for each pair of independent variables, *(source: self study)*

Pair of independent variables	**Polynomial**	**Pair of independent variables**	**Polynomial**
(C, K)	$Y^*_1 = 0{,}8012 + 0{,}0013\,C - 0{,}813K$	(I, K)	$Y^*_{22} = 0{,}7122 - 0{,}0643K$
(K, I)	$Y^*_2 = 0{,}7293 - 0{,}07K$	(I, C)	$Y^*_{23} = 0{,}3749 + 0{,}0001\,I - 0{,}0047C$
(K, H)	$Y^*_3 = 1{,}0225 - 0{,}1287W - 0{,}1250\,Hc$	(S, R)	$Y^*_{24} = 0{,}5847 + 0{,}0066S - 0{,}0022R$
(Q, R)	$Y^*_4 = 0{,}7533 - 0{,}0450Q - 0{,}0023R$	(S, Q)	$Y^*_{25} = -3{,}5810 + 0{,}1707 - 1{,}1117Q$
(Q, S)	$Y^*_5 = -3{,}5810 + 1{,}1117Q + 0{,}1707S$	(S, W)	$Y^*_{26} = 0{,}7609 + 0{,}0015S - 0{,}0694W$
(Q, I)	$Y^*_6 = -0{,}2739 + 0{,}1123Q - 0{,}0003I$	(S, C)	$Y^*_{27} = 0{,}5254 + 0{,}0104S - 0{,}0073C$
(Q, S_c)	$Y^*_7 = 0{,}5349 - 0{,}0219Q - 0{,}1489Sc$	(R, Q)	$Y^*_{28} = 0{,}7533 - 0{,}0023R - 0{,}0450Q$
(C, Q)	$Y^*_8 = 0{,}8012 + 0{,}0013C - 0{,}0813Q$	(R, W)	$Y^*_{29} = 0{,}8133 + 0{,}0007R - 0{,}0900W$
(C,R)	$Y^*_9 = 0{,}6890 + 0{,}0129C - 0{,}0062R$	(R, C)	$Y^*_{30} = 0{,}6890 - 0{,}0062R + 0{,}0129C$
(C, S)	$Y^*_{10} = 0{,}5254 - 0{,}0073C + 0{,}0104S$	(Q, W)	$Y^*_{31} = 0{,}8000 - 0{,}0100Q - 0{,}0700W$
(C, I)	$Y^*_{11} = 0{,}3749 - 0{,}0047C - 0{,}0001I$	(Q, C)	$Y^*_{32} = 0{,}7922 - 0{,}0722Q - 0{,}0078C$
(C, H)	$Y^*_{12} = 0{,}4228 + 0{,}0034C - 0{,}2138H$	(W, C)	$Y^*_{33} = 0{,}8012 - 0{,}0812W - 0{,}0013C$
(H, I)	$Y^*_{13} = 0{,}4028 + 0{,}1246H - 0{,}0001I$	(W, Q)	$Y^*_{34} = 0{,}8000 - 0{,}0700W - 0{,}0100Q$
(H, S)	$Y^*_{14} = 0{,}4553 + 0{,}1461H - 0{,}0033S$	(W, R)	$Y^*_{35} = 0{,}8133 - 0{,}0900W - 0{,}0007R$
(H, R)	$Y^*_{15} = 0{,}3275 + 0{,}2903H - 0{,}0022R$	(W, S)	$Y^*_{36} = 0{,}7609 - 0{,}0694W - 0{,}0015S$
(H, Q)	$Y^*_{16} = 0{,}5349 + 0{,}1489H - 0{,}0219Q$	(R, S)	$Y^*_{37} = 0{,}5847 - 0{,}0022R + 0{,}0066S$
(H, W)	$Y^*_{17} = 1{,}0225 - 0{,}1250H - 0{,}1288W$	(R, I)	$Y^*_{38} = 0{,}4594 - 0{,}0017R + 0{,}0001I$
(H, C)	$Y^*_{18} = 0{,}4228 + 0{,}2138\,H - 0{,}0034C$	(R, H)	$Y^*39 = 0{,}3275 + 0{,}0022R + 0{,}2903H$
(I, S)	$Y^*_{19} = 0{,}0976 + 0{,}0004I - 0{,}0192S$	(S, I)	$Y^*_{40} = 0{,}0976 - 0{,}0192S + 0{,}0004I$
(I, R)	$Y^*_{20} = 0{,}4594 + 0{,}0001I - 0{,}0017R$	(S, H)	$Y^*_{41} = 0{,}4553 + 0{,}0033S + 0{,}1461H$
(I, Q)	$Y^*_{21} = -0{,}2739 + 0{,}0003I + 0{,}1123Q$	(I, H)	$Y^*_{42} = 0{,}4028 + 0{,}0001I + 0{,}1246H$

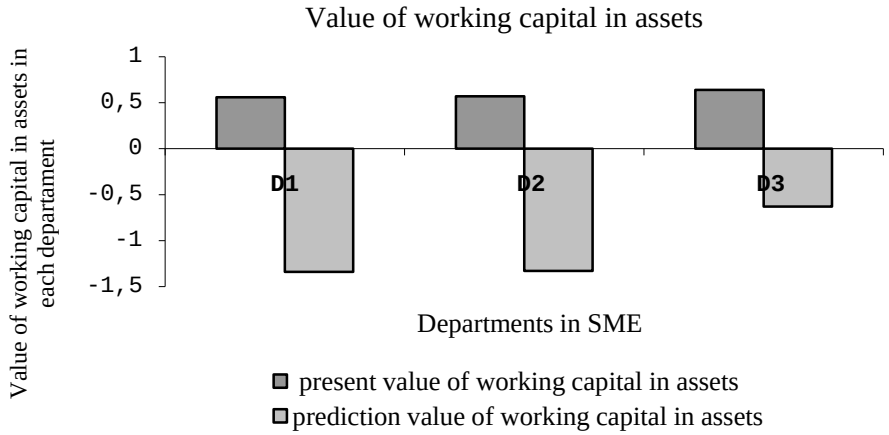

Figure 6. Prediction value of knowledge in the SME sector using the model 1
(source: self study)

So, the best possible polynomial (decision model) in relation to share working capital in assets indicators binding the selected criteria of the characteristics of the knowledge-workers is defined:

$$Y^*_{31} = Y^*_{34} = 0{,}8000 - 0{,}0700\ K - 0{,}0100\ Q \qquad (1)$$

or, as secondly

$$Y^*_{41} = 0{,}4553 + 0{,}0033\ S + 0{,}1461 H \qquad (2)$$

For a company, investing in the knowledge-workers comes down to organizing trainings for the sell-managers. Using the model (1) the effects f investments in knowledge-workers in the SME sector (prediction value of share working capital in assets) is forecasted (Fig. 6).

So, investing in the intellectual capital (training for sell-manager) is not profitable, because the value of the potential benefits (prediction value of share working capital in assets) is not acceptable for the management of the SME sector company.

But, when for a company investing in the knowledge-workers comes down to changing the organisation culture, the analysis results are acceptable for management in SME. Using the model (2) the effects of investments in knowledge-workers in the SME sector (prediction value of share working capital in assets) is forecasted (Fig. 7).

As a result, on the basis of the obtainable prediction values, it was recommended to the company to investment in building an organization's culture based on confidence. Trust and confidence are both the target the strategy and determinants of strategy preferences. Trust is voluntary and linked to shared values [Tonkiss and Passey, 1999]. Confidence in knowledge-workers management should be interest centre both employee and management.

The matrix of the characteristics of the knowledge-workers will help assessing rationality and effectivenes of investing in employee skills, namely training for employees. Future research include developing a system of indicators which, on the one hand, will reflect funding spent on training and, on the other, will include measures to show effects of such investment. Indicators, defined on the basis of experience among SMEs which invested in knowledge and operate ERP tools, will comprise a base of parameters and indicators necessary to build a system supporting decision making at a strategic level as regards profitability of investing in knowledge. It means that, for some companies, the assessment of the effects which investment in knowledge would bring can be done on the basis of previously defined indicators.

Developing a decision making model will start with collecting information on the more research subject. These are empirical data obtained through observation of SMEs operation. Model identification indicators enabling to asses rationality and effectiveness of knowledge based on measurement of input and output data from SMEs studies using GMDH algorhytm.

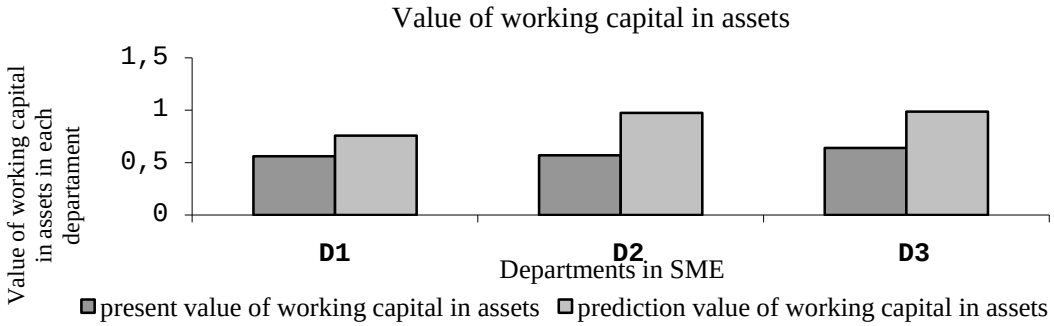

Figure 7. Prediction value of knowledge in the SME sector using the model 2
(source: self study)

5. Concluding remarks

Companies operating in a market economy need to introduce changes in systems of organisation and management. In business practice, decision making in a company depends on activity, competition, changing external factors, e.g. technical advancement, and results achieved by research and development departments. Knowledge, employees' skills, social relations, know-how, and in particular effective investment in intellectual are an added value for a company. Companies investing in human capital and work systems acquire competitive advantage thanks to their readiness to learn and adopting new qualifications as well as efficient communication and information channels.

The model which has been introduced in this paper gives more possibilities in the area of profitability of the investment in knowledge. The research which is in progress is focused on the development of the SME knowledge database of characteristics of the knowledge-workers. A decisive nature of an undertaken problem imposes the structural model of identification.

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ABDUCTIVE REASONING DRIVEN APPROACH TO PROJECT - LIKE PRODUCTION FLOW PROTOTYPING

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Abstract: Constraint Programming (CP) is an emergent software technology for declarative description and effective solving of large combinatorial problems especially in the area of integrated production planning. In that context, CP can be considered as an appropriate framework for development of decision making software supporting scheduling of multi-robot in a multi-product job shop. The paper deals with multi-resource problem in which more than one shared renewable and non-renewable resource type may be required by manufacturing operation and the availability of each type is time-windows limited. The problem belongs to a class of NP-complete ones. The aim of the paper is to present a knowledge based and CLP-driven approach to multi-robot task allocation providing a prompt service to a set of routine queries stated both in straight and reverse way. Provided examples illustrate both cases while taking into account an accurate as well as an uncertain specification of robots and workers operation time.

Key words: knowledge engineering, modeling, constraints logic programming, scheduling.

1. Introduction

Some industrial processes simultaneously produce different products using the same production resources. An optimal assignment of available resources to production steps in a multi-product job shop is often economically indispensable. The goal is to generate a plan /schedule of production orders for a given period of time while minimizing the cost that is equivalent to maximization of profit. In that context executives want to know how much a particular production order will cost, what resources are needed, what resources allocation can guarantee due time production order completion, and so on. So, a manager's needs might be formulated in a form of standard, routine questions, such as: Does the production order can be completed before an arbitrary given deadline? What is the production completion time following assumed robots operation time? Is it possible to undertake a new production order under given (constrained in time) resources availability while guaranteeing disturbance-free execution of the already executed orders? What values and of what variables guarantee the production order will completed following assumed set of performance indexes?

The problems standing behind of the quoted questions belong to the class of so called project scheduling ones. In turn, project scheduling can be defined as the process of allocating scarce resources to activities over a period of time to perform a set of activities in a way taking into account a given performance measure. Such problems belong to NP-complete ones. Therefore, the new methods and techniques addressing the impact of real-life constraints on the decision making is of great importance, especially for interactive and task oriented DSSs designing [4, 8].

Several techniques have been proposed in the past fifty years, including MILP, Branch-and-Bound [6] or more recently Artificial Intelligence. The last sort of techniques concentrates mostly on fuzzy set theory and constraint programming frameworks. Constraint Programming/Constraint Logic Programming (CP/CLP) languages [6, 18] seems to be well suited for modeling of real-life and day-to-day decision-making processes in an enterprise [5]. In turn, applications of fuzzy set theory in production management [19] show that most of the research on project scheduling has been focused on fuzzy PERT and fuzzy CPM [12, 13].

In this context, the contribution provides the framework allowing one to take into account both: distinct (pointed), and imprecise (fuzzy) data, in a unified way and treated in a unified form of a discrete, constraint satisfaction problem (CSP) [4]. The approach proposed

concerns of logic-algebraic method (LAM) based and CP-driven methodology aimed at interactive decision making based on distinct and imprecise data. The paper can be seen as continuation of our former works concerning projects portfolio prototyping [5, 11].

The following two classes of standard routine queries are usually considered and they are formulated in:

a straight way (i.e. corresponding to the question: What results from premises?)

- what the portfolio makespan follows from the given project constraints specified by activity duration times, resources amount and their allocation to projects' activities?
- does a given resources allocation guarantee the production orders makespan do not exceed the given deadline?
- does the projects portfolio can be completed before an arbitrary given deadline?

a reverse way (i.e. corresponding to the question: What implies conclusion?)

- what activity duration times and resources amount guarantee the given production orders portfolio makespan do not exceed the deadline?
- does there exist resources allocation such that production orders makespan do not exceed the deadline?
- does there exist a set of activities' operation times guaranteeing a given projects portfolio completion time will not exceed the assumed deadline?

Above mentioned categories encompass the different reasoning perspectives, i.e. deductive and abductive ones.

The corresponding queries can be stated in different models that in turn may be treated as compositions of variables and constraints, i.e. assumed sets of variables and constraints limiting their values. In that context both an enterprise and the relevant production orders can be specified in terms of distinct and/or imprecise variables, discrete and/or continuous variables, renewable and/or non-renewable resources, limited and/or unlimited resources, and so on.

Possible problems formulation taking into account commercially available software packages capabilities is shown in the Table 1. So, that is easy to observe that commercially available tools are not able to consider cases assuming imprecise data as well as are not able to state a problem in an reverse way (e.g., looking for values of some input variables guaranteeing the assumed output variables reach required values).

Moreover, the commercially available DSSs are not able to respond in an interactive, i.e. on-line/real-time mode, as well as to support a project-like production flow prototyping (i.e. integrated production planning containing such partial problems as routing, batch-sizing and scheduling).

That disadvantage is our motivation to develop methodology supporting one in the course of designing of an interactive and task oriented decision support systems aimed at projects portfolio prototyping. By projects prototyping we mean a decision process resulting in selection (variables adjustment) both an enterprise and projects portfolio parameters fulfilling assumed requirements, e.g. an admissible solution being a kind of an equilibrium between enterprise capabilities and projects' cost and make span.

Table 1. Possible problems formulation available in commercially available software packages perspective *(source: self study)*

DSS	variables		resources		queries	
	precise	imprecise	renewable	non-renewable	straight	reverse
Primavera	✓	×	✓	×	✓	×
Planiswere	✓	×	✓	×	✓	×
Tracker Suite	✓	×	✓	×	✓	×
Project Net	✓	×	✓	×	✓	×
Team Work	✓	×	✓	×	✓	×
…	…	…	…	…	…	...
MS Project	✓	×	✓	×	✓	×

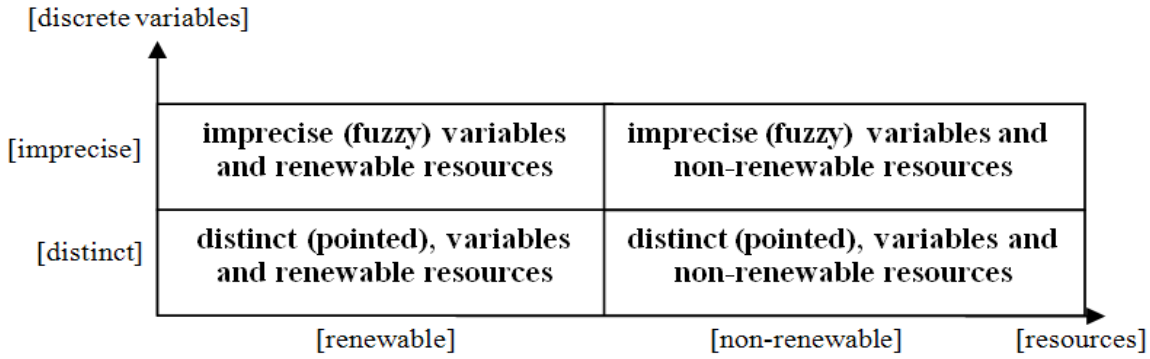

Figure 1. Elementary decision problems *(source: self study)*

An approach proposed assumes a kind of reference model encompassing open structure enabling one to take into account different sorts of variables and constraints as well as to formulate straight and reverse kind of project planning problems. So, the elementary as well as hybrid models can be considered, see the Fig. 1. Of course, the most general case concerns of the hybrid model specified by discrete distinct and/or imprecise (fuzzy) variables and renewable and/or non-renewable resources.

Note that assumed model enabling descriptive way of a problem statement encompasses constraint satisfaction problem structure and then allows implementing the problem considered in constraint programming environment. That is because the constraint programming treated as programming paradigm enables to specify both variables and relations between them in the form of constraints and then to implement them in the one of popular constraint logic languages such as: **CHIP V5**, **ECLiPSe**, and **SICStus**, or imperative constraint programming languages (assuming that a statement computation results in a program state change) such as: **Choco**, **ILOG**, and **python-constraint**, or public domain concurrent constraint programming language as **Oz Mozart**.

In that context the methodology proposed consists of the following three stages, see Fig. 2. At the first stage the reference model of constraint satisfaction problem is considered. That means that on the base of available specifications of a small and medium sized enterprise and projects portfolio as well as the assumed routine queries and possible auxiliary (suggested by experts) knowledge a relevant **reference model of constraint satisfaction problem** is designed. The model encompasses technical parameters, experts' experience and user expectations in the form of knowledge base, i.e. as a set of variables, and their domains, and a set of relations (constraints, e.g. time-window resource availability) linking some subsets of constraints. Such model's interpretation allows using the logic-algebraic method as a reference engine.

At the second stage, the knowledge base obtained is examined from the point of view of its future implementation in assumed, implementing CP framework, real-life DSS. Since the CP framework is useless in case variables can be gathered in disjoint clusters and is useless also for queries checking whether a given subset of variables implies other one, thus the knowledge base (KB) consistency (guaranteeing response to the set of assumed queries) and its discrepancy (guaranteeing the unique response to each query) point of view must be examined.

Besides of that, the KB has to be examined also from the point of view of the time efficiency of possible searching strategies (especially variables distribution). That means the searching strategy guaranteeing an interactive DSS operation has to be developed. The above mentioned examinations guarantee the KB specification can be directly implemented in CP framework (that means the straight and reverse problems' formulation and queries such as whether a given subset of variables implies other one can be considered).

Therefore, the third stage transforms the knowledge-based and CP-driven framework into the commercially available CP/CLP platforms (i.e., taking advantage of the fact the decision problems can be friendly formulated in a declarative way, and solved with guarantee the response DO NOT KNOW will not be allowed). So, besides of the right constraint programming

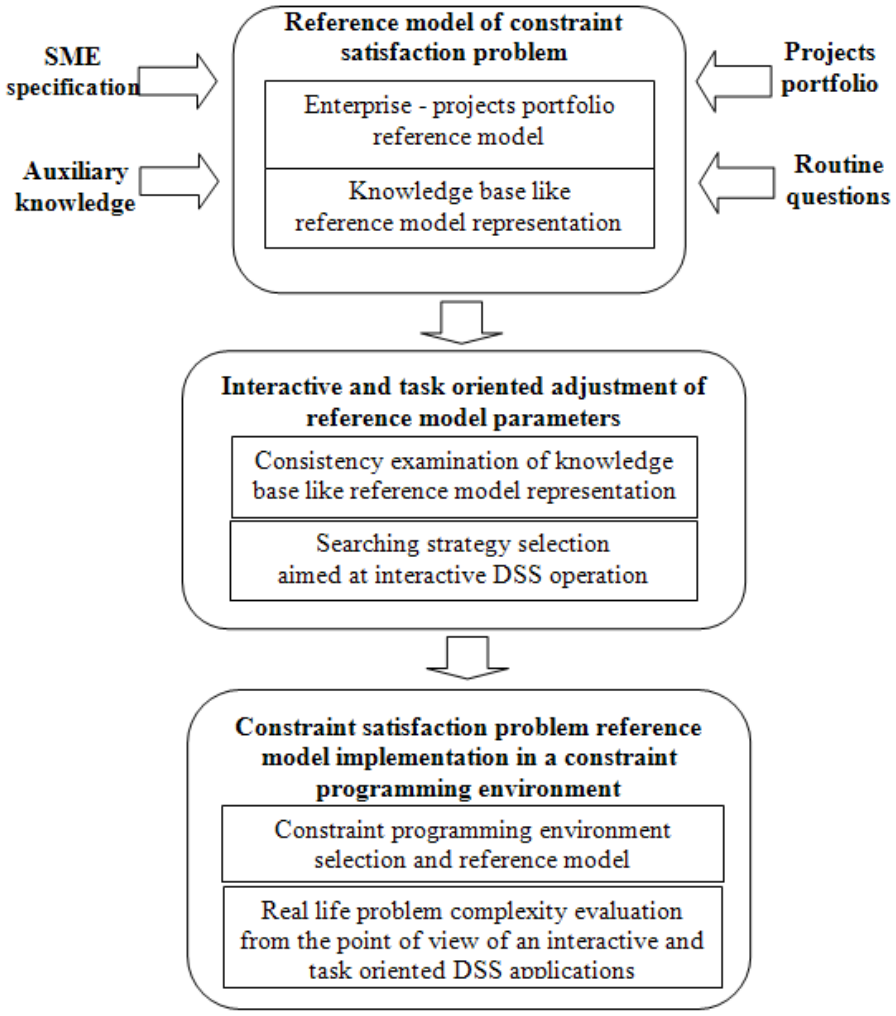

Figure 2. Main stages of an interactive and task oriented DSS designing *(source: self study)*

environment selection and the reference model implementation the complexity of a class of real life problems guaranteeing an interactive DSS application should be estimated.

Of course, in case of imprecise decision variables the one more so called preliminary stage has to be considered. The main aim of the stage is identification of membership functions in case of imprecise decision variables as well as verification of inference fuzzy rules implemented.

2. Modelling

2.1. Decision problem

Both kinds of queries distinguished in the Section 1 (i.e. concerning the straight and reverse problems formulation) assumes at least one feasible solution there exists. That means, the class of so called decision problems focusing on the question whether any feasible solution there exists should be stated at first. Then, following from the guarantee a set of feasible solutions is not empty the class of so called optimization problems can be considered as well.

In this contribution, we concentrate on the first kind of problems, i.e. decision ones. So, the sets of considered queries are aimed at searching for feasible solutions while are formulated in the straight or reverse ways. Typical queries of both kinds are: Does the given resources allocation guarantee the duration time of considered projects portfolio do not exceed the assumed deadline? What values and of what variables if any guarantee the duration time of considered projects portfolio do not exceed the assumed deadline?

In case the optimal solutions are sought, i.e. optimization problems are considered, the above mentioned questions have to be reformulated, for instance as follow: What resources allocation results in shortest makespan of considered projects portfolio? What are the optimal values and of what variables guarantee the considered projects portfolio completion time is due date? In that context the problem of production process planning in an small and medium sized enterprise (SME) environment seen as projects portfolio scheduling can be treated either as searching for such resources allocation, or as searching for such adjustment of arbitrarily chosen variables which guarantees the required values of assumed performance indexes hold. Both kinds of problems can be stated and resolved then in terms of so called reference model of decision problem, see the section bellow.

2.2. Reference model of decision problem

Let us consider the reference model of a decision problem concerning of multi-resource task allocation in a multi-product job shop assuming imprecise character of decision variables. The model specifies both the job shop capability and production orders requirement in a unified way, i.e., through the description of determining them sets of variables and sets of constraints restricting domains of discrete variables. Some conditions concerning the routine questions are included in the set of constraints. That means in case such conditions hold the response to associated questions is positive. Of course, in order to avoid confusion the constraints guaranteeing the responses DO NOT KNOW are not allowed are also taken into account. In that context, the reference model aimed at the following routine question: Does a given job shop capabilities and assumed resources allocation guarantee the production orders completion time do not exceed the deadline h and amount of renewable resources is positive in any moment of time horizon H?

Given amount of lz of renewable discrete resources ro_i specified by: $Ro = (ro_1, ro_2,\ldots, ro_z)$. Given amounts $zo_{i,k}$ of available renewable resources $zo_i = (zo_{i,1}, zo_{i,2}, \ldots, zo_{i,h})$, where $zo_{i,k}$ – limited amount of the i-th renewable resource at the k-th moment of H, specified by $Zo = (zo_1, zo_2,\ldots, zo_{lz})$.

Given amount ln of non-renewable resources rn_i specified by: $Rn = (rn_1, rn_2,\ldots, rn_{ln})$. Given amounts zn_i of available non-renewable resources rn_i specified by $Zn = (zn_1, zn_2,\ldots, zn_{ln})$, where zn_i denotes amount of the resource rn_i being available at the beginning of time horizon H.

Decision variables

Given a set of production routes $P = \{P_1, P_2,..., P_{lp}\}$. Each P_i is specified by the set composed of lo_i activities, i.e., $P_i = \{O_{i,1},\ldots,O_{i,loi}\}$, where [2]:

$$O_{i,j} = (x_{i,j},t_{i,j},Tp_{i,j},Tz_{i,j},Dp_{i,j},Tr_{i,j},Ts_{i,j},Cr_{i,j},Cs_{i,j}) \quad (1)$$

where:

$x_{i,j}$ – means the starting time of the activity $O_{i,j}$, i.e., the time counted from the beginning of the time horizon H

$t_{i,j}$ – the duration of the $O_{i,j}$-th activity

$Tp_{i,j} = (tp_{i,j,1}, tp_{i,j,2},... , tp_{i,j,lz})$ – the sequence of time moments the activity $O_{i,j}$ requires new amounts of renewable resources: $tp_{i,j,k}$ – the time counted since the moment $x_{i,j}$ of the $dp_{i,j,k}$ amount of the k-th resource allocation to the activity $O_{i,j}$. That means a resource is allotted to an activity during its execution period: $0 \le tp_{i,j,k} < t_{i,j}$; k = 1,2,…,lz

$Tz_{i,j} = (tz_{i,j,1}, tz_{i,j,2},... , tz_{i,j,lz})$ – the sequence of moments the activity $O_{i,j}$ releases the subsequent resources, $tz_{i,j,k}$ – the time counted since the moment $x_{i,j}$ of the $dp_{i,j,k}$ amount of the k-th renewable resource was released by the activity $O_{i,j}$.. That is assumed a resource is released by activity during its execution: $0 < tz_{i,j,k} \le t_{i,j}$ and $tp_{i,j,k} < tz_{i,j,k}$; k = 1, 2,…, lz

$Dp_{i,j} = (dp_{i,j,1}, dp_{i,j,2},..., dp_{i,j,lz})$ – the sequence of the k-th resource amounts $dp_{i,j,k}$ are allocated to the activity $O_{i,j}$, i.e., $dp_{i,j,k}$ – the amount of the k-th resource allocated to the activity $O_{i,j}$. That assumes: $0 \le dp_{i,j,k} \le zo_k$; k = 1, 2,…, lz

$Tr_{i,j} = (tr_{i,j,1}, tr_{i,j,2}, ..., tr_{i,j,ln})$ – the sequence of moments the determined amounts of subsequent non renewable resources are collected by activity $O_{i,j}$: $tr_{i,j,k}$ – the time counted since the moment $x_{i,j}$ the $dp_{i,j,k}$ amount of the k-th non renewable resource was released by the activity $O_{i,j}$. That is assumed a resource is collected by activity during its execution: $0 \le tr_{i,j,k} < t_{i,j}$; k = 1, 2,…, ln

$Ts_{i,j} = (ts_{i,j,1}, ts_{i,j,2}, ..., ts_{i,j,ln})$ - the sequence of moments the determined amounts of subsequent non renewable resources are generated (released) by activity $O_{i,j}$: $ts_{i,j,k}$ - the time counted since the moment $x_{i,j}$ the $cs_{i,j,k}$. amount of the k-the non renewable resource was generated by the activity

$O_{i,j}$. That is assumed the resource is generated during activity execution, however not earlier than beginning of its collection, i.e.: $0 \le ts_{i,j,k} < t_{i,j}$; k = 1, 2,…, ln, as well as $tr_{i,j,k} \le ts_{,j,k}$; k = 1, 2, …, ln

$Cr_{i,j} = (cr_{i,j,1}, cr_{i,j,2},... , cr_{i,j,ln})$ – the sequence of non-renewable resources amount consumed by activity $O_{i,j}$, $cr_{i,j,k}$ – the amount of the k-th resource required by the activity $O_{i,j}$, $cr_{i,j,1} \le 0$; k = 1, 2,…, ln, $cr_{i,j,k} = 0$ means the activity does not consume the k-th resource

$Cs_{i,j} = (cs_{i,j,1}, cs_{i,j,2},..., cs_{i,j,ln})$ – the sequence of amounts of non-renewable resources released by activity $O_{i,j}$, $cs_{i,j,k}$ – the amount of the k-th resource inflowed by activity $O_{i,j}$, $cs_{i,j,1} \ge 0$; k = 1,2,…,ln, $cr_{i,j,k} = 0$ means the activity does not inflow the k-th resource

Consequently, each activity $O_{i,j}$ is specified by the following sequences of:

- starting times of activities in the route P_i:

  $X_i = (x_{i,1}, x_{i,2},…, x_{i,lo_i})$, $0 \le x_{i,j} < h$
  i = 1, 2,…, lp; j = 1, 2,…, lo_i

- duration of activities in the route P_i:

  $Ti = (ti, 1, ti, 2,…, t_{i,lo_i})$

- starting times the j-th resource is allocated to the k-th activity in the route P_i:

  $TP_{i,j} = (tp_{i,1,j},..., tp_{i,k,j},..., tp_{i,lo_i,j})$

- starting times the j-th resource is released by the k-th activity in the P_i:

  $TZ_{i,j} = (tz_{i,1,j}, tz_{i,2,j},..., tz_{i,lo_i,j})$

- amounts of the j-th resources allotted to the k-th activity in the route P_i:

  $DP_{i,j} = (dp_{i,1,j}, dp_{i,2,j},…, dp_{i,lo_i,j})$

- the sequence of moments the j-th non renewable resource is collected by activities of the projects P_i:

  $TR_{i,j} = (tr_{i,1,j}, tr_{i,2,j}, … , tr_{i,lo_i,j})$

- the sequence of moments the j-th non renewable resource is released by activities of the project P_i:

  $TS_{i,j} = (ts_{i,1,j}, ts_{i,2,j}, … , ts_{i,lo_i,j})$

- sequences of amounts of the j-th non-renewable resource consumed by activities of the route P_i:

  $CR_{i,j} = (cr_{i,1,j}, cr_{i,2,j},…, cr_{i,lo_i,j})$

- sequences of amounts of the j-th non-renewable resource inflowed by activities of the route P_i:

  $CS_{i,j} = (cs_{i,1,j}, cs_{i,2,j},…, cs_{i,lo_i,j})$

Assume some of chosen execution times are defined roughly, i.e. are treated as fuzzy variables specified by fuzzy sets. Therefore, the activity $O_{i,j} = (\hat{x}_{i,j}, \hat{t}_{i,j}, Tp_{i,j}, Tz_{i,j}, Dp_{i,j}, Tr_{i,j}, Ts_{i,j}, Cr_{i,j}, Cs_{i,j})$ is specified by the following sequences of:

- starting times of activities in the route P_i:

  $\hat{X}_i = (\hat{x}_{i,1}, \hat{x}_{i,2}, … , \hat{x}_{i,lo_i})$

- duration of activities in the route P_i:

  $\hat{T}_i = (\hat{t}_{i,1}, \hat{t}_{i,2}, … , \hat{t}_{i,lo_i})$

where:

$\hat{X}_i$– is a fuzzy set determining the activity $O_{i,j}$ starting time,

$\hat{T}_i$ – is a fuzzy set specifying the activity time,

$Tp_{i,j}$, $Tz_{i,j}$, $Dp_{i,j}$, $Tr_{i,j}$, $Ts_{i,j}$, $Cr_{i,j}$, $Cs_{i,j}$ – the sequences defined by (1).

Activities order constraints

Let us consider a set of production routes P_i composed of lo_i precedence and resource constrained, non-preemptable activities that require renewable resources. Assume lz renewable discrete resources are available and sequences $r_i = (ro_1, ro_2,…, ro_f)$, i = 1,…,$lo_i$, determines fixed discrete resource requirements of the i-th activity. The total number of units of the discrete resource j, j = 1,…, lz, is limited by zo_j. The resource can be allotted (and constant within activity operation time) to activities in arbitrary amount from the set {1,…, zo_j}. It means two different resources can be allotted to the i-th activity at different also overlapping each other periods of time.

The production routes P_i are represented by activity-on-node networks, where activities state for nodes and arcs determine an order of activities execution. Consequently, assuming discrete decision variables the following activities order constraints are considered [2]:

- the k-th activity follows the *i*-th one :

$$x_{i,j} + t_{i,j} \le x_{i,k} \tag{2}$$

- the *k*-th activity follows other activities:

$$\begin{aligned} &x_{i,j}+t_{i,j} \le x_{i,k,} \\ &x_{i,j+1}+t_{i,j+1} \le x_{i,k} \\ &\dots \\ &x_{i,j+n}+t_{i,j+n} \le x_{i,k} \end{aligned} \tag{3}$$

- the k-th activity is followed by other activities:

$$\begin{aligned} &x_{i,k} + t_{i,k} \le x_{i,j} \\ &x_{i,k} + t_{i,k} \le x_{i,j+1} \\ &\dots \\ &x_{i,k}+t_{i,k} + \le x_{i,,j+n} \end{aligned} \quad (4)$$

In the case fuzzy value of variables the constraints (2), (3), (4) have following form [3]:

- the k-th activity follows the *i*-th one :

$$\hat{x}_{i,j} \hat{+} \hat{t}_{i,j} \hat{\le} \hat{x}_{i,k} \quad (5)$$

- the k-th activity follows other activities:

$$\begin{aligned} &\hat{x}_{i,j} \hat{+} \hat{t}_{i,j} \hat{\le} \hat{x}_{i,k} \\ &\hat{x}_{i,j+1} \hat{+} \hat{t}_{i,j+1} \hat{\le} \hat{x}_{i,k} \\ &\dots \\ &\hat{x}_{i,j+n} \hat{+} \hat{t}_{i,j+n} \hat{\le} \hat{x}_{i,k} \end{aligned} \quad (6)$$

- the k-th activity is followed by other activities

$$\begin{aligned} &\hat{x}_{i,j} \hat{+} \hat{t}_{i,j} \hat{\le} \hat{x}_{i,k+1} \\ &\hat{x}_{i,j} \hat{+} \hat{t}_{i,j} \hat{\le} \hat{x}_{i,k+2} \\ &\hat{x}_{i,j} \hat{+} \hat{t}_{i,j} \hat{\le} \hat{x}_{i,k+n} \end{aligned} \quad (7)$$

The relevant fuzzy arithmetic operations $\hat{+}$, $\hat{\le}$, are defined in the Appendix A. Due to the formulas (a8), (a12), see the Appendix A, any fuzzy constraint C_i (e.g. $\hat{v}_i \hat{<} \hat{v}_l$) can be characterized by the logic value $E(C_i)$, $E(C_i) \in [0,1]$. In turn, values $E(C_i)$ allow to determine the level of uncertainty DE of reference model's constraints satisfaction, i.e. a kind of uncertainty threshold. For instance, DE = 1 means the all constraints hold, and DE = 0,8 means that they are almost satisfied. The level DE is defined due to the formulae (8):

$$DE = \min_{i=1,2,\dots,lo_c}\{E(C_i)\} \quad (8)$$

where:

lo_c – a number of reference model constraints.

In the course of decision making based on constraints assuming fuzzy variables an uncertainty threshold (e.g. following an operator's experience) should be assumed. That means, the decision maker should be able to decide about the membership functions of the decision variables used as well as uncertainty thresholds of fuzzy constraints employed.

Renewable resource constraints

The constraints avoiding exceeding of resources available limits play a primary role. That means, the relevant constraints taking into account precise/imprecise character of such decision variables as activities operation times $t_{i,j}/\hat{t}_{i,j}$ and the moments of activities beginning $x_{i,j}/\hat{x}_{i,j}$ have to be considered. The approach proposed follows the way applied in case of distinct variables [2]. Note that exceeding available resources limit exceeding may result in bad resources allocation leading to the closed loops of resources requests. So, the constraints allowing one to avoid such cases follow formulas (9), (10):

$$\sum_{i=1}^{lp}\sum_{j=1}^{lo_i}\left[dp_{i,j,k} \cdot \bar{1}(x_{m,n} + tp_{m,n,k}, x_{i,j} + tp_{i,j,k}, x_{i,j} + tz_{i,j,k})\right] \le zo_{k,x_{m,n}+tp_{m,n}-1} \quad (9)$$

$\forall\ (m,n) \in \{(a,b) \mid a = 1,2,\dots,lp,\ b = 1,2,\dots,lo_a\}$, $\forall k \in \{1, 2, \dots, lz\}$

and

$$\sum_{i=1}^{lp}\sum_{j=1}^{lo_i}\left[dp_{i,j,k} \cdot \bar{1}(vg_{k,d}, x_{i,j} + tp_{i,j,k}, x_{i,j} + tz_{i,j,k},)\right] \le zo_{k,vg_{k,d}-1} \quad (10)$$

$\forall d \in \{1,2,\dots,q\}, \forall k \in \{1, 2, \dots, lz\}$

where:

lp – the number of projects, lo_i – the number of activities in the i-th project,

$dp_{i,j,k}$ – the number of resources of the k-th resource used by the activity $O_{i,j}$,

$\bar{1}(u, a, b)$ – an unary function determining the time of the resource occupation,

$\bar{1}(u, a, b) = 1(u - a) - 1(u - b), 1(u)$ - the unit step function,

$vg_{k,i}$ - the *i*-th characteristic point, it is moment $u \in H$ when amount of renewable resource ro_i changes value,

q – number of the characteristic points.

Similarly to constraints concerning precise variables the relevant ones taking into account imprecise data follow the formula (11) [2, 3]:

$$\sum_{i=1}^{lp}\sum_{j=1}^{lo_i}\Big[dp_{i,j,k} \cdot \hat{\bar{1}}\big(\hat{x}_{m,n} \hat{+} tp_{m,n,k}, \hat{x}_{i,j} \hat{+} tp_{i,j,k}, \hat{x}_{i,j} \hat{+} tz_{i,j,k}, E_{\hat{1},i,j,m,n}\big)\Big] \le zo_k \quad (11)$$

$\forall\ (m,n) \in \{(a,b) \mid a = 1, 2, \dots, lp,\ b = 1, 2, \dots, lo_a\}$ $\forall k \in \{1, 2, \dots, lz\}$

where:

$\hat{\bar{1}}(\hat{g}, \hat{a}, \hat{b}, E_{\hat{1}}) = \hat{1}(\hat{g}, \hat{a}, E_{\hat{1}}) - \hat{1}(\hat{g}, \hat{b}, E_{\hat{1}})$ – an unary fuzzy function determining the time of recourse occupation, $\hat{1}(\hat{v}, \hat{a}, E_{\hat{1}}) \in \{0,1\}$- the unit fuzzy function.

$$\hat{1}(\hat{g}, \hat{a}, E_{\hat{1}}) = 1 - \frac{E_{\hat{1}} - E(\hat{g} \hat{\ge} \hat{a})}{1 - 2E(\hat{g} \hat{\ge} \hat{a})} \quad (12)$$

where:

$\hat{a}, \hat{b}, \hat{g}$ – the fuzzy numbers,

$E_{\hat{1}} \in [0,1]$ – the logic value of unit fuzzy function, $E_{\hat{1},i,j,m,n}$ – the logic value of i,j-th an unary fuzzy function for pair (m,n).

In case considered, see (11) the amounts $zo_{k,i}$ of available renewable resources are assumed to be constant in whole horizon H: $zo_{k,1} = zo_{k,2} = \ldots = zo_{k,h} = zo_k$ [3].

If for any moment $\hat{x}_{m,n}$ (where: $(m,n) \in \{(a,b) \mid a = 1, 2,\ldots, lp, b = 1, 2,\ldots, lo_a\}$) and for each ro_k-th renewable resource $k \in \{1, 2,\ldots, lz\}$, conditions (11) hold, then projects portfolio execution will deadlock free (and conflict-free) with the uncertainty level $DEf = \min\{E_{\hat{1},i,j,m,n}\}$.

Non-renewable resource constraints

Because of limited amount of available discrete non-renewable resources the constraints protecting against their allocation exceeding available outflows should also be considered. Moreover, because non-renewable resources can be allotted at the same time to different activities in a way causing in occurrence of closed loop resources requests, i.e. the deadlocks. In order to avoid them the relevant constraints should be imposed. By analogy to renewable resources allocation the constraints guaranteeing deadlock-free execution of activities (treated as precise variables) are considered [2, 3]:

$$zn_k - \sum_{i=1}^{lp}\sum_{j=1}^{lo_i}\left[cr_{i,j,k} \cdot \bar{1}\left(x_{m,n} - x_{i,j} - tr_{i,j,k}\right)\right] + \sum_{i=1}^{lp}\sum_{j=1}^{lo_i}\left[cs_{i,j,k} \cdot \bar{1}\left(x_{m,n} - x_{i,j} - ts_{i,j,k}\right)\right] \geq 0 \quad (13)$$

$\forall (m,n) \in \{(a,b) \mid a = 1 , 2,\ldots, lp; b = 1, 2,\ldots, lo_a\}$

$\forall k \in \{1, 2,\ldots, ln\}$

where:

lp – the number of projects,

lo_i – the number of the i-th project's activities,

1(v) – the unit step function,

$cr_{i,j,k}$ – the amount of the k-th resource required by the activity $O_{i,j}$,

$cs_{i,j,k}$ – the amount of the k-th resource flowed by activity $O_{i,j}$, zn_k denotes amount of the resource rn_k being available at the beginning of time horizon H.

In case of imprecise variables the constraints guaranteeing deadlock-free execution of activities follow formulae (13), see [3]:

$$zn_k - \sum_{i=1}^{lp}\sum_{j=1}^{lo_i}\left[cr_{i,j,k} \cdot \hat{1}\left(\hat{x}_{m,n}, \hat{x}_{i,j} \hat{+} tr_{i,j,k}, E_{\hat{1},i,j,m,n}\right)\right] + \sum_{i=1}^{lp}\sum_{j=1}^{lo_i}\left[cs_{i,j,k} \cdot \hat{1}\left(\hat{x}_{m,n}, \hat{x}_{i,j} \hat{+} ts_{i,j,k}, E_{\hat{1},i,j,m,n}\right)\right] \geq 0$$

$\forall (m,n) \in \{(a,b) \mid a = 1, 2, \ldots, lp; b = 1, 2, \ldots, lo_a\}$

$\forall k \in \{1, 2, \ldots, ln\}$ (14)

where:

lp – the number of projects,

lo_i – the number of the i-th project's activities,

$\hat{1}\left(\hat{v}, \hat{a}, E_{\hat{1},i,j,m,n}\right)$ – the fuzzy unit function (12),

zn_k – denotes amount of the resource rn_k being available at the beginning of time horizon H.

If at any moment $\hat{x}_{m,n}$ (where: $(m,n) \in \{(a,b) \mid a = 1, 2,\ldots, lp, b = 1, 2,\ldots, lo_a\}$) for each rn_k-th nonrenewable resource $k \in \{1, 2, \ldots, ln\}$ conditions (11) hold, then projects portfolio execution is deadlock-free with the uncertainty level $DEf = \min\{E_{\hat{1},i,j,m,n}\}$.

2.3. Constraint satisfaction problem

Constraint programming (CP) is an emergent software technology for declarative description and effective solving of large combinatorial problems, especially in the areas of integrated production planning. Since a constraint can be treated as a logical relation among several variables, each one taking a value in a given (usually discrete) domain, the idea of CP is to solve problems by stating the requirements (constraints) that specify a problem at hand, and then finding a solution satisfying all the constraints [4]. Because of its declarative nature, it is particularly useful for applications where it is enough to state what has to be solved instead how to solve it [4].

More formally, CP is a framework for solving combinatorial problems specified by pairs: <a set of variables and associated domains, a set of constraints restricting the possible combinations of the values of the variables>. So, the constraint satisfaction problem (CSP) [4] is defined as follows: CS = ((A, D), C), where: A = $\{a_1, a_2,..., a_g\}$ – a finite set of discrete decision variables, D = $\{D_i \mid D_i = \{d_{i,1}, d_{i,2},..., d_{i,,j},..., d_{i,,ld}\}$, i = 1,..., g} – a family of finite variable domains and the finite set of constraints C = $\{C_i \mid i = 1,\ldots, L\}$ – a finite set of constraints limiting the variables domain. The solution to the CS is a vector $(d_{1,i}, d_{2,k},\ldots, d_{n,j})$ such that the entry assignments satisfy all the constraints C. So, the task is to find the values of variables satisfying all the constraints, i.e., a feasible valuation.

The inference engine consists of the following two components: constraint propagation and variable distribution. Constraints propagation uses constraints actively to prune the search space. The aim of propagation techniques, i.e., local consistency checking, is to reach a certain level of consistency in order to accelerate search procedures by drastically reducing the size of the search tree [3]. The constraints propagation ex-

ecutes almost immediately. What limits the size of the problem in practical terms is the variable distribution phase, which employs the backtracking-based search and is very time consuming as a result.

The declarative character of CP languages and their high efficiency in solving combinatorial problems offer an attractive alternative to the currently available DSSs that employ operation research techniques.

3. Decision support tool for project portfolio prototyping

The considered Decision Support Tool for Project Portfolio Prototyping (DST4P^3) aimed at project planning in small and medium sized enterprises (SME) has been developed in Oz Mozart [17] and Delphi languages environment. The main components of the DST4P^3 structure are shown in Fig. 3. The system considered is composed of two modules serving for computations and interfacing, respectively. Of course, the main role plays the first module responsible for implementation of the reference model (see chapter 2) specified in terms of the fuzzy constraint satisfaction problem [9] (implementing fuzzy variables and fuzzy constraints (5), (6), (7), (11), (14)) and operation of an inference engine (implementing the logic-algebraic method) operation [8, 10].

Moreover, the module employs procedures enabling constraint compression and time effective searching strategies [6] as well as a newly introduced algebraic and logic operations allowing to calculate fuzzy constraints including fuzzy numbers [3, 9].

The second module of the DST4P^3 enables problems specification, i.e. input data insertion, and queries selection, as well as an output data visualization and documentation. The following kinds of project planning problems are allowed:

- "straight" with distinct variables specifying the SME at hand,
- "straight" with imprecise variables specifying the SME at hand,
- "reverse" with distinct variables specifying the SME at hand,
- "reverse" with distinct variables specifying the SME at hand.

Illustrative examples of the DST4P^3 (fig. 3) application to the above mentioned problems provide the section below.

4. Illustrative examples

Example 1 – „straight"/distinct variables

Given the following projects portfolio, i.e. the set of projects $P = \{P_1, P_2, P_3, P_4\}$. Activities $O_{i,j}$ of projects are specified by corresponding sets: $P_1 = \{O_{1,1},\ldots, O_{1,10}\}$, $P_2 = \{O_{2,1},\ldots, O_{2,12}\}$, $P_3 = \{O_{3,1},\ldots, O_{3,11}\}$, $P_4 = \{O_{4,1},\ldots, O_{4,13}\}$. The relevant activity networks [2] are shown on the following figures: Fig. 4, Fig. 5, Fig. 6, and Fig. 7.

Given the time horizon $H = \{0, 1,\ldots, 40\}$. Operation times for particular projects P_1, P_2, P_3, P_4 are determined by the following sequences:

$T_1 = (1, 2, 3, 4, 4, 8, 3, 2, 1, 6)$

$T_2 = (3, 1, 6, 3, 2, 5, 1, 5, 2, 4, 2, 1)$

$T_3 = (3, 7, 2,7, 2, 1,8, 3, 3, 4, 8)$

$T_4 = (3, 3, 2, 8, 3, 1, 4, 1, 8, 4, 3, 3, 8)$

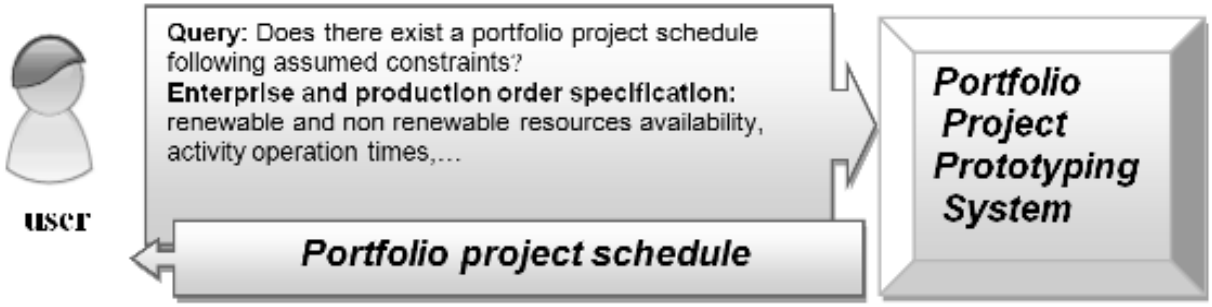

Figure 3. Mains components of DST4P^3 structure *(source: self study)*

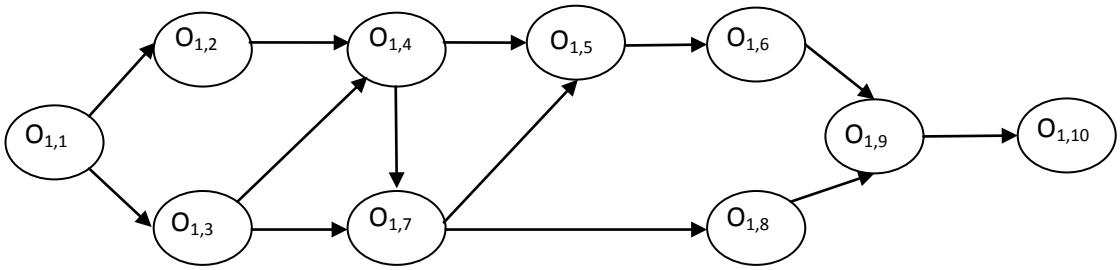

Figure 4. Activity network for the project P_1 *(source: self study)*

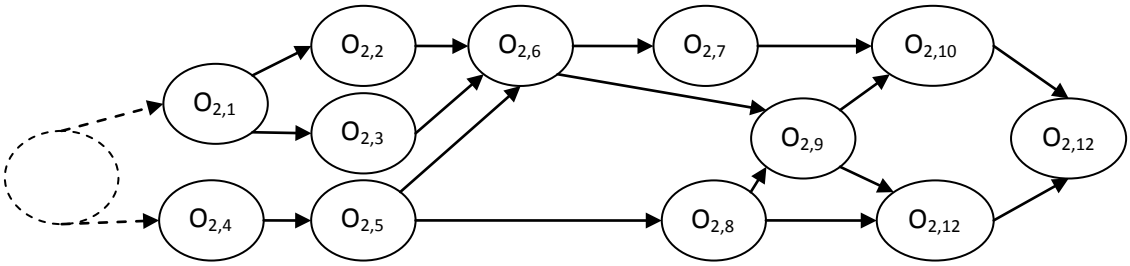

Figure 5. Activity network for the project P_2 *(source: self study)*

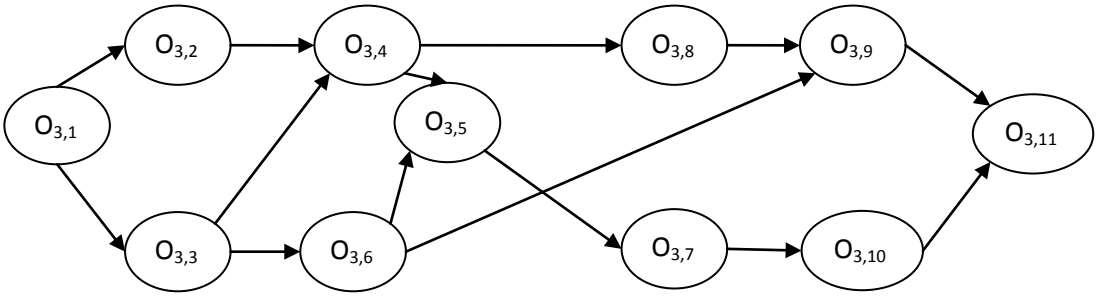

Figure 6. Activity network for the project P_3 *(source: self study)*

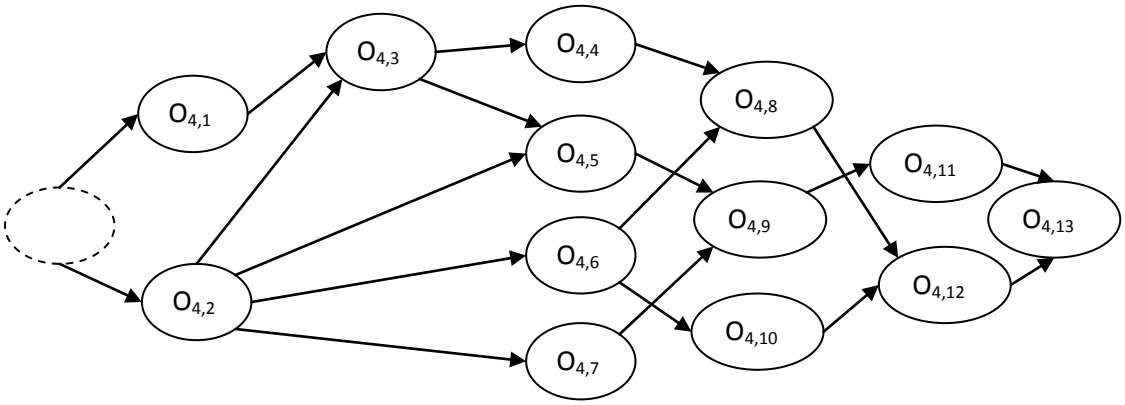

Figure 7. Activity network for the project P_4 *(source: self study)*

Given are three kinds of renewable resources ro_1, ro_2, ro_3. Resources' amounts are limited by following units number: 11, 14, 12, respectively. Resource amounts are constant in whole time horizon H. That is assumed the relevant amount of resources required by particular activity can be released only by this activity and only at the moment of its completion. The amounts of particular resources required by projects' P_1, P_2, P_3, P_4 activities are given in the following tables: Table 2, Table 3, Table 4, and Table 5.

That is assumed some activates besides of renewable resources require also non-renewable resources. Given are two kinds of non-renewable resources rn_1, rn_2. Initial amount of the resource rn_1 is equal to 10 units, and of the resource rn_2 is equal to 7 units. Activities may use up and generate some number of resources rn_1, rn_2 units. That is assumed each activity uses up some resource units at the beginning and generates some resource units at the activity's end. The amounts of used up and generated resource rn_1 units determine sequences: $CR_{i,j}$, $CS_{i,j}$ respectively in the following tables: Table 6, Table 7, Table 8, and Table 9.

Table 2. Amounts of resources required by activities of the project P1 *(source: self study)*

	$O_{1,1}$	$O_{1,2}$	$O_{1,3}$	$O_{1,4}$	$O_{1,5}$	$O_{1,6}$	$O_{1,7}$	$O_{1,8}$	$O_{1,9}$	$O_{1,10}$
$DP_{1,1}$	3	1	1	1	1	1	2	1	2	1
$DP_{1,2}$	2	1	2	1	1	2	3	3	1	1
$DP_{1,3}$	2	2	3	1	1	1	1	1	2	1

Table 3. Amounts of resources required by activities of the project P2 *(source: self study)*

	$O_{2,1}$	$O_{2,2}$	$O_{2,3}$	$O_{2,4}$	$O_{2,5}$	$O_{2,6}$	$O_{2,7}$	$O_{2,8}$	$O_{2,9}$	$O_{2,10}$	$O_{2,11}$	$O_{2,12}$
$DP_{2,1}$	4	3	2	2	1	1	1	3	1	2	2	2
$DP_{2,2}$	1	2	3	1	2	1	2	1	1	2	1	1
$DP_{2,3}$	2	1	1	1	3	1	2	2	2	1	1	1

Table 4. Amounts of resources required by activities of the project P3 *(source: self study)*

	$O_{3,1}$	$O_{3,2}$	$O_{3,3}$	$O_{3,4}$	$O_{3,5}$	$O_{3,6}$	$O_{3,7}$	$O_{3,8}$	$O_{3,9}$	$O_{3,10}$	$O_{3,11}$
$DP_{3,1}$	2	4	1	2	2	2	1	2	2	1	3
$DP_{3,2}$	2	1	3	2	2	2	1	1	1	2	2
$DP_{3,3}$	2	4	1	2	2	2	1	2	2	1	3

Table 5. Amounts of resources required by activities of the project P4 *(source: self study)*

	$O_{4,1}$	$O_{4,2}$	$O_{4,3}$	$O_{4,4}$	$O_{4,5}$	$O_{4,6}$	$O_{4,7}$	$O_{4,8}$	$O_{4,9}$	$O_{4,10}$	$O_{4,11}$	$O_{4,12}$	$O_{4,13}$
$DP_{4,1}$	1	2	3	4	3	2	2	1	1	1	3	1	4
$DP_{4,2}$	1	1	1	2	1	2	1	3	2	2	2	1	2
$DP_{4,3}$	1	2	2	1	1	2	4	1	2	2	2	1	2

Table 6. Amount of used up (CR) and generated (CS) non-renewable resources required by activities of the project P1 *(source: self study)*

	$O_{1,1}$	$O_{1,2}$	$O_{1,3}$	$O_{1,4}$	$O_{1,5}$	$O_{1,6}$	$O_{1,7}$	$O_{1,8}$	$O_{1,9}$	$O_{1,10}$
$CR_{1,1}$	1	1	2	1	2	1	3	1	1	1
$CR_{1,2}$	1	2	1	1	1	0	1	0	1	1
$CS_{1,1}$	3	2	0	2	4	4	2	0	2	4
$CS_{1,2}$	1	2	3	2	2	2	0	2	1	2

Table 7. Amount of used up (CR) and generated (CS) non-renewable resources required by activities of the project P2 *(source: self study)*

	$O_{2,1}$	$O_{2,2}$	$O_{2,3}$	$O_{2,4}$	$O_{2,5}$	$O_{2,6}$	$O_{2,7}$	$O_{2,8}$	$O_{2,9}$	$O_{2,10}$	$O_{2,11}$	$O_{2,12}$
$CR_{2,1}$	1	0	1	2	1	1	1	3	1	0	1	1
$CR_{2,2}$	3	2	1	2	0	2	3	2	2	2	1	2
$CS_{2,1}$	3	2	0	2	1	2	0	2	0	2	0	1
$CS_{2,2}$	3	2	1	2	0	2	3	2	2	2	1	2

Table 8. Amount of used up (CR) and generated (CS) non-renewable resources required by activities of the project P3 *(source: self study)*

	$O_{3,1}$	$O_{3,2}$	$O_{3,3}$	$O_{3,4}$	$O_{3,5}$	$O_{3,6}$	$O_{3,7}$	$O_{3,8}$	$O_{3,9}$	$O_{3,10}$	$O_{3,11}$
$CR_{3,1}$	1	1	2	1	1	1	0	1	3	1	1
$CR_{3,2}$	0	1	1	0	2	1	1	1	3	1	0
$CS_{3,1}$	2	3	2	0	2	1	2	2	2	3	2
$CS_{3,2}$	3	2	1	2	0	2	3	2	2	2	1

Table 9. Amount of used up (CR) and generated (CS) non-renewable resources required by activities of the project P4 *(source: self study)*

	$O_{4,1}$	$O_{4,2}$	$O_{4,3}$	$O_{4,4}$	$O_{4,5}$	$O_{4,6}$	$O_{4,7}$	$O_{4,8}$	$O_{4,9}$	$O_{4,10}$	$O_{4,11}$	$O_{4,12}$	$O_{4,13}$
$CR_{4,1}$	1	1	2	1	1	1	0	1	3	1	1	1	1
$CR_{4,2}$	0	1	1	0	2	1	1	1	3	1	0	1	1
$CS_{4,1}$	2	3	2	0	2	1	2	2	2	3	2	3	2
$CS_{4,2}$	3	2	1	2	0	2	3	2	2	2	1	2	2

Let us assume each project's efficiency is measured by Net Present Value (*NPV*) performance index calculated due to the following formulae:

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+k)^t}$$

where:

CFt – the money netto flow expected in the year t,

k – the discount rate (alternative capital investment cost),

n – the period of a project exploitation [years].

The problem considered belongs to the class of „straight" ones and reduces to the following question: Does there exist a schedule following constraints assumed on availability of renewable and non-renewable resources and NPV > 0 such that production orders completion time not exceeds the deadline h?

Solution to the problem results in determination of moments the activities start their execution $x_{i,j}$ [8]. So, the solution we are searching for has the form of the following sequences: $X_1 = (x_{1,1},\ldots, x_{1,10})$, $X_2 = (x_{2,1},\ldots, x_{2,12})$, $X_3 = (x_{3,1},\ldots, x_{3,11})$, $X_4 = (x_{4,1},\ldots, x_{4,13})$.

The graphical representation of the projects portfolio schedule is shown in the Fig. 8. The schedule obtained follows all constrains imposed by an enterprise capacity and projects execution requirements. The system considered allows one to obtain the Gantt's-like chart illustrating the rates of resources usage both renewable and non-renewable ones.

An example of graphical representation of the resource zo_1 usage rate containing assumed resource's limit in whole time horizon is shown on Fig. 9. It can be observed the assumed resource's limit was not exceeded, the same regards of resources zo_2, zo_3.The Fig. 10 in turn illustrates changes regarding the rate of resource usage concerning of the non-renewable resource zn_2. That is easy to note that the assumed minimal level of resource usage equal to 0 was never exceeding in whole time horizon. The same remark concerns the resource zn_1.

Therefore, the example presented illustrates the main capabilities of the DST4P[3] package possessing capability of multi-criteria project planning (e.g. taking into account a particular project deadline, projects portfolio deadline, resources limits, and so on) and an interactive approach to projects prototyping problems formulated either in a straight or in a reverse way. The problem of the size just considered took less than 5 minutes (the AMD Athlon(tm)XP 2500 + 1,85 GHz, RAM 1,00 GB platform has been used).

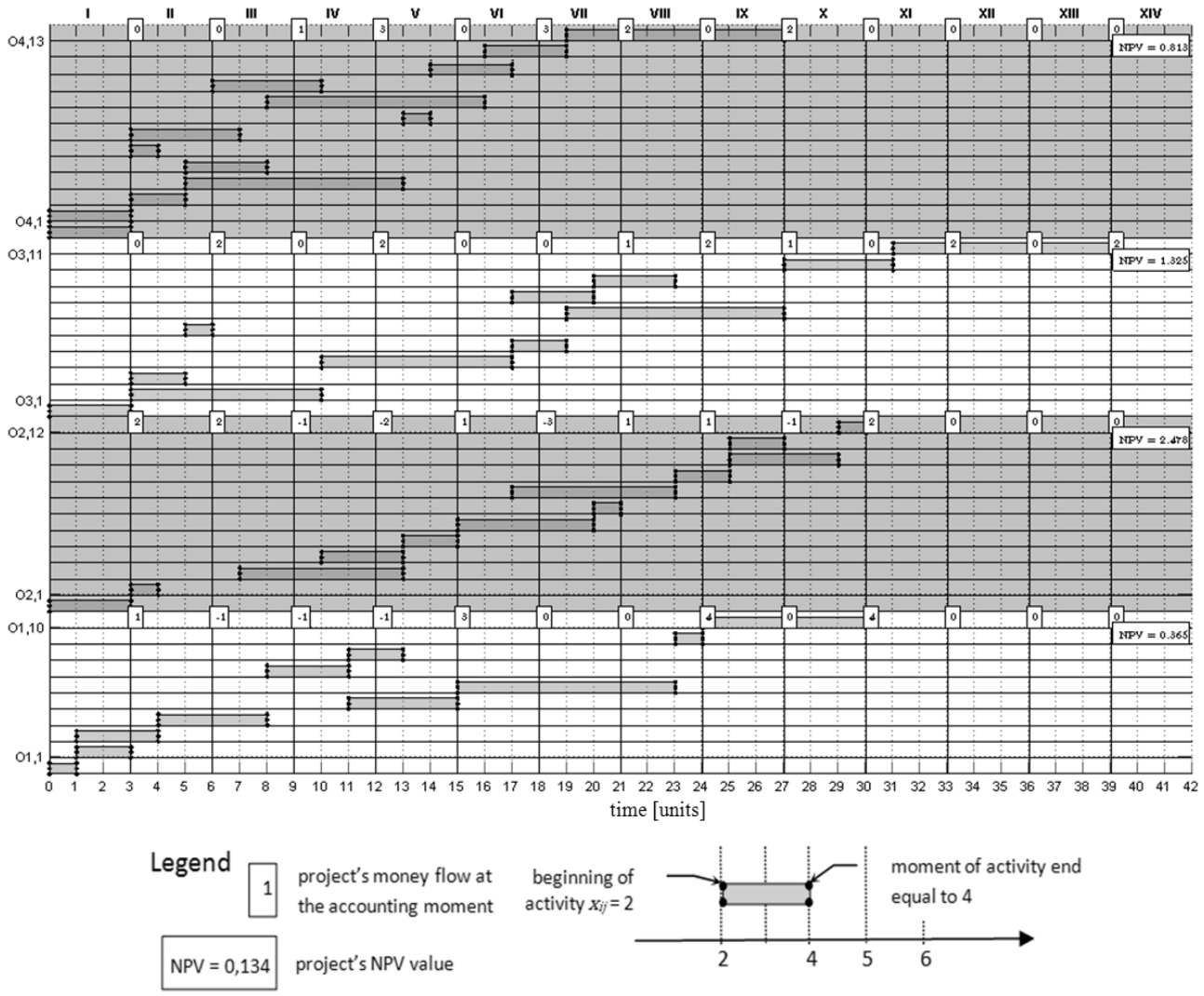

Figure 8. Projects portfolio schedule *(source: self study)*

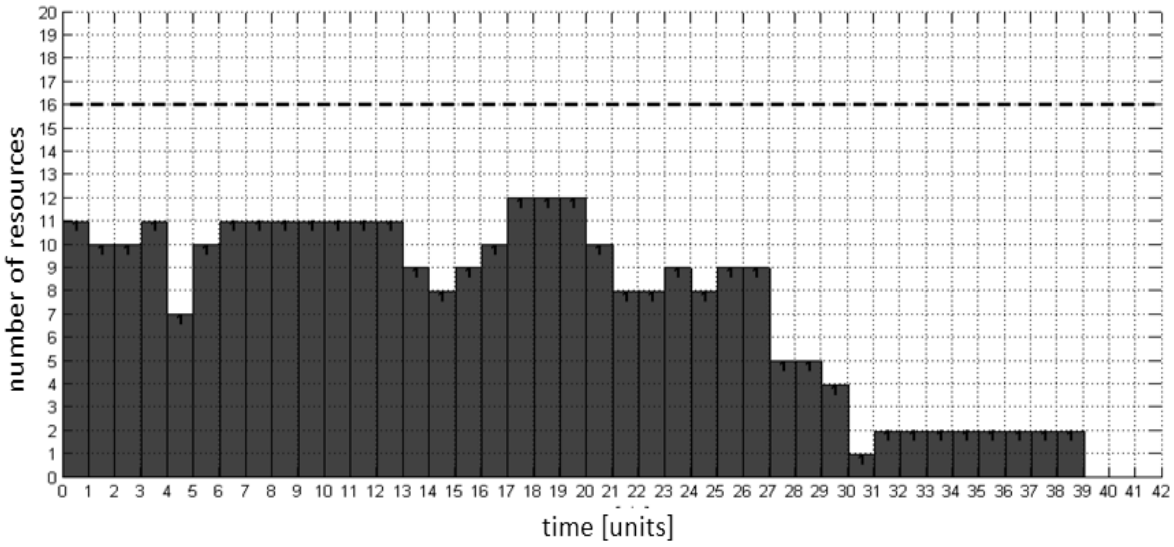

Figure 9. Gantt's-like chart of the renewable resource zo1 usage *(source: self study)*

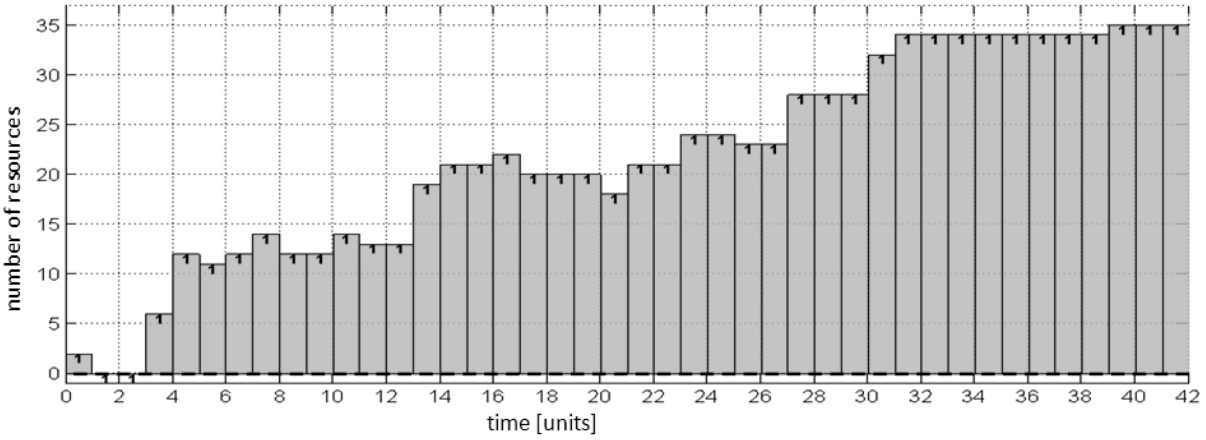

Figure 10. Gantt's-like chart of the non-renewable resource zn2 usage *(source: self study)*

Example 2 – „straight"/distinct variables

Given the following projects portfolio, i.e. the set of projects P = {P_1, P_2, P_3, P_4} specified by the same activity networks (see Fig. 4, Fig. 5, Fig. 6 and Fig. 7) and resources allocations (see the Table 2 – Table 9) as in the Example 1. However, the new time horizon H = {0, 1,…, 36} is considered.

The problem considered belongs to the class of „straight" ones and reduces to the following question: Does there exist a schedule following constraints assumed on availability of renewable and non-renewable resources and NPV > 0 such that production orders completion time not exceeds the deadline h?

Similarly to the previous case the solution to the problem results in determination of the moments activities start their execution $x_{i,j}$. So, the solution we are searching for has the same form of the following sequences: $X_1 = (x_{1,1},\ldots, x_{1,10})$, $X_2 = (x_{2,1},\ldots, x_{2,12})$, $X_3 = (x_{3,1},\ldots, x_{3,11})$, $X_4 = (x_{4,1},\ldots, x_{4,13})$, however regards of the shorter deadline.

In the case considered, in 2 seconds, the DST4P[3] package's response was: *Lack of any solutions.* That means no schedule there exists. In such situation, however there is still a possibility to reformulate the problem considered by stating it in terms of imprecise variables, i.e. looking for a solution specified by an uncertainty measure. Such the case is just considered below.

Example 3 – „straight"/imprecise variables

Given the following projects portfolio, i.e. the set of projects P = {P_1, P_2, P_3, P_4} specified by the same activity networks (see Fig. 4, Fig. 5, Fig. 6 and Fig. 7) and resources allocations (see Table 2 – Table 9) as in the Example 1. In case considered the industrial robots guaranteeing distinct operation times and workers responsible for imprecise operation times are treated as available renewable resources. However, the new time horizon $H = \{0,1,\ldots,36\}$ is considered.

Given the uncertainty threshold value DE ≥ 0,7 limiting uncertainty of constraints specifying projects portfolio. So, DE determines the minimal grade value guaranteeing the all constraints hold. For instance, DE = 0,9 means that the makespan of the projects portfolio considered will hold within the given time horizon H. Moreover, the operations times of activities: $O_{1,6}$, $O_{1,10}$, $O_{2,3}$, $O_{2,6}$, $O_{2,8}$, $O_{3,2}$, $O_{3,4}$, $O_{3,7}$, $O_{3,11}$, $O_{4,4}$, $O_{4,9}$, $O_{4,13}$ have an imprecise character. So, the relevant sequences of activities' operation times are as follow:

$\hat{T}_1$ = (1, 2, 3, 4, 4, "about 6", 3, 2, 1, "about 4")

$\hat{T}_2$ = (3, 1, "about 4", 3, 2, "about 3", 1, "about 4", 2, 4, 2, 1)

$\hat{T}_3$ = (3, "about 5", 2, "about 5", 2, 1, "about 6", 3, 3, 4, "about 6")

$\hat{T}_4$ = (3, 3, 2, „about 6", 3, 1, 4, 1, „about 6", 4, 3, 3,"about 6")

For instance, in the case the activity's $O_{1,6}$ operation time is „about 6" (see Fig. 11) that means the activity can be executed within the time period of 4 till 8 units of time. In order to be able to distinguish crispy and imprecise variables the following symbol „^" is used.

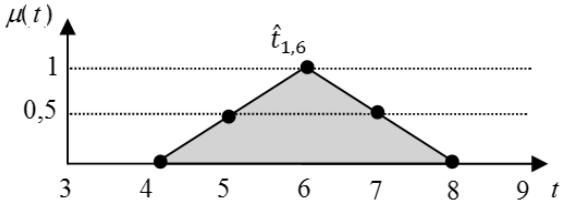

Figure 11. $\hat{t}_{1,6}$ = "about 6 " *(source: self study)*

The problem considered belongs to the class of „straight" ones and reduces to the following question: Does there exist a schedule following constraints assumed on availability of renewable and non-renewable resources and NPV > 0 such that production orders completion time not exceeds the deadline h with the uncertainty threshold DE ≥ 0,7 ?

The proposed problem formulation assumes the solutions obtained are imprecise, so their implementation can be risky because of such uncertainty. Moreover we assume some variables e.g. operations times, and uncertainty threshold value DE are imprecise.

Similarly to the Example 1 the solution to the problem results in determination of the moments activities start their execution $x_{i,j}$. So, the solution we are searching for has the same form of the following sequences: $X_1 = (x_{1,1},\ldots, x_{1,10})$, $X_2 = (x_{2,1},\ldots, x_{2,12})$, $X_3 = (x_{3,1},\ldots, x_{3,11})$, $X_4 = (x_{4,1},\ldots x_{4,13})$, however regards of the shorter deadline, as in the Example 2.

The first admissible solution provided by DST4P[3] (obtained in 10 s) has the following form:

X_1 = (0, 1, 1, 4, 11, 15, 8, 11, 22, 23)

X_2 = (0, 3, 10, 10, 13, 15, 19, 18, 23, 25, 25, 29)

X_3 = (0, 3, 3, 9, 15, 5, 17, 15, 18, 24, 28)

X_4 = (0, 0, 3, 5, 5, 3, 3, 13, 8, 6, 14, 16, 19)

The NPV index value calculated for projects: P_1, P_2, P_3, P_4 follow the requirement NPV > 0, i.e. NPV_{P1} = 0,3649, NPV_{P2} = 2,6024, NPV_{P3} = 1,6177, NPV_{P4} = 0,8165.

The graphical representation of the projects portfolio schedule is show in the Fig. 12. The schedule obtained follows all constrains imposed by an enterprise capacity and projects execution requirements.

Obtained schedule provides the plan for projects portfolio execution, where uncertainty threshold level for all constraints is equal or less than 0,7 (that one may interpret as a risk of due time completion on the level equal to 0,3).

The level the planed schedule fits its real live execution depends on a decision maker. The way such fitting can be adjusted is show in the Example 5.

The system considered allows one to obtain the Gantt's-like chart illustrating the rates of resources usage both renewable and non-renewable ones. An example of graphical representation of the renewable resource zo_4 usage rate containing assumed resource's limit (equal to 12 units) in whole time horizon is shown on Fig. 14.

Assumed resource's limit is distinguished by bold and dashed line. The chart considered provides information about the number of currently used resources units. For instance (see Fig. 13), between the first and the second unit of time there are used six resource units (i.e. with certainty equal to 1).

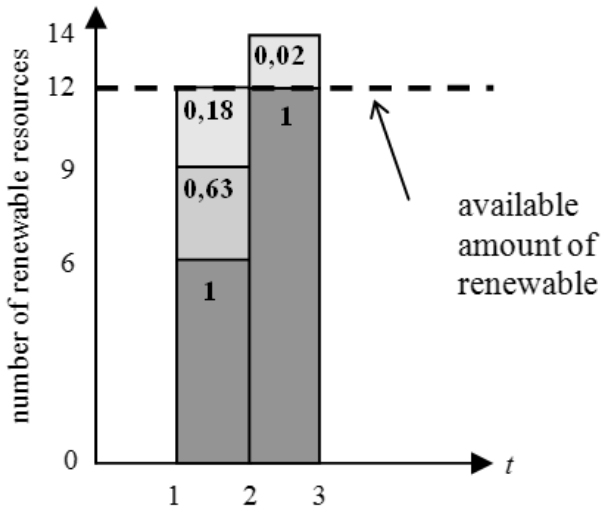

Figure 13. Illustration of the renewable resource usage rate estimation *(source: self study)*

That number changes, however with uncertainty level, for instance with the uncertainty level equal to 0,18, the 12 resource units are required. In turn, in the period between the second and the third units of time a risk level equal to 0,02 resulting in exceeding the assumed resource limit (by two units) is observed.

The similar cases concerning the resource limits exceeding can be observed for the resource zo_3 (see Fig. 14). That means, due to the schedule from Fig. 12, resource shortage may occur at the following time units 12, 15 and 19.

Quite similar observations regards of the non-renewable resource zn_2 see Fig. 15. In this case, however any risk of the resource shortage does not occur. In turn, the constraint determining the minimal, i.e. equal to 0, amount of renewable resources holds in both kinds of resources in whole time horizon.

The problem of the size just considered took less than 1 minute (the AMD Athlon(tm)XP 2500 + 1,85 GHz, RAM 1,00 GB platform has been used).

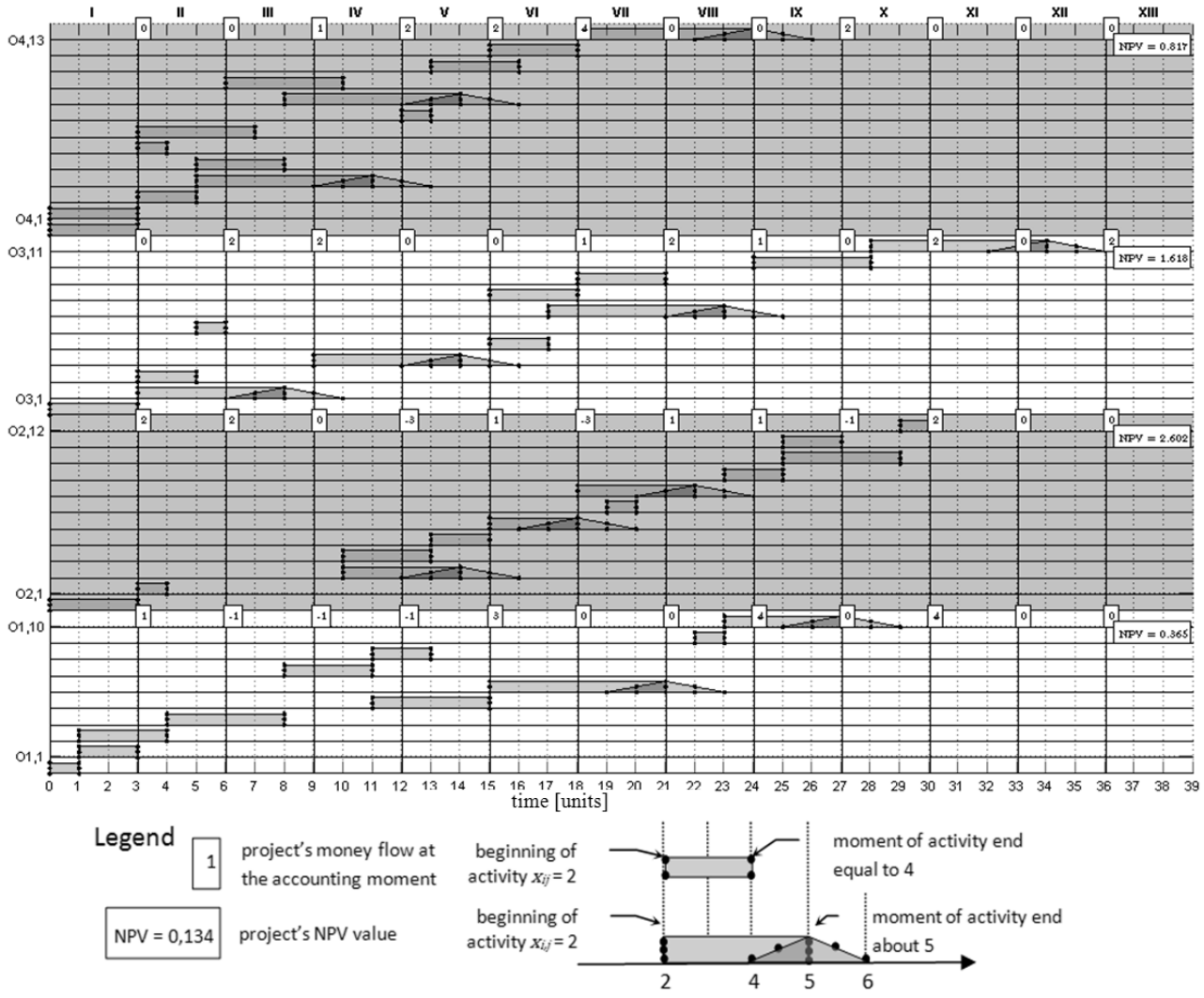

Figure 12. Projects portfolio schedule with the uncertainty threshold ≥ 0,7 *(source: self study)*

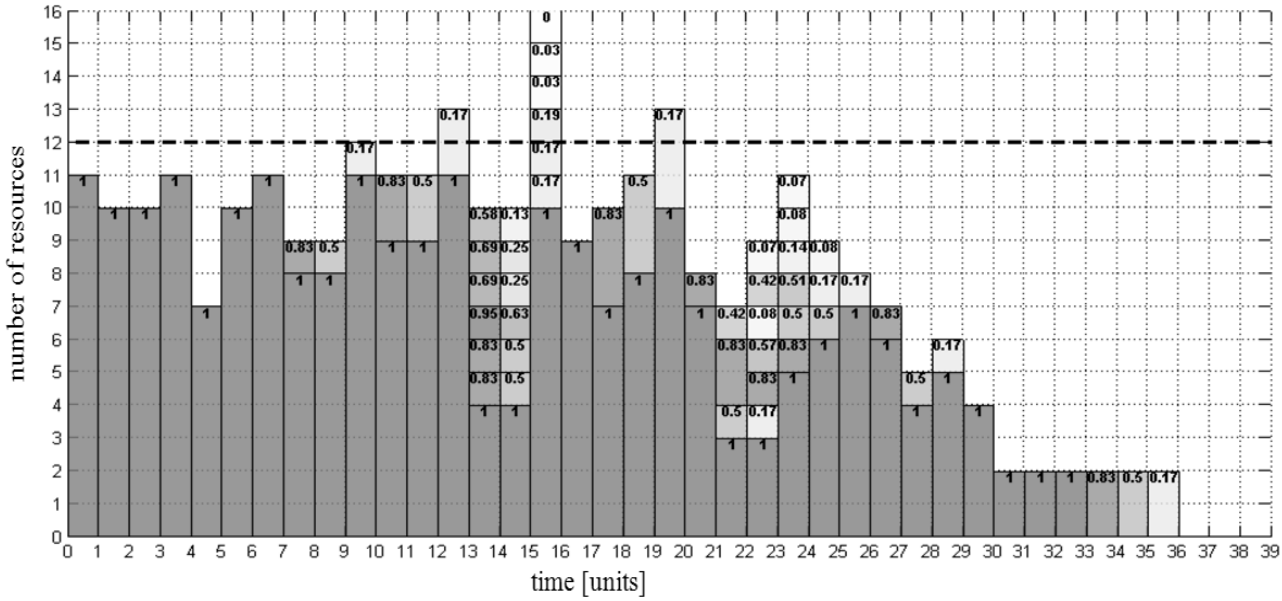

Figure 14. Usage rate of renewable resource zo3 *(source: self study)*

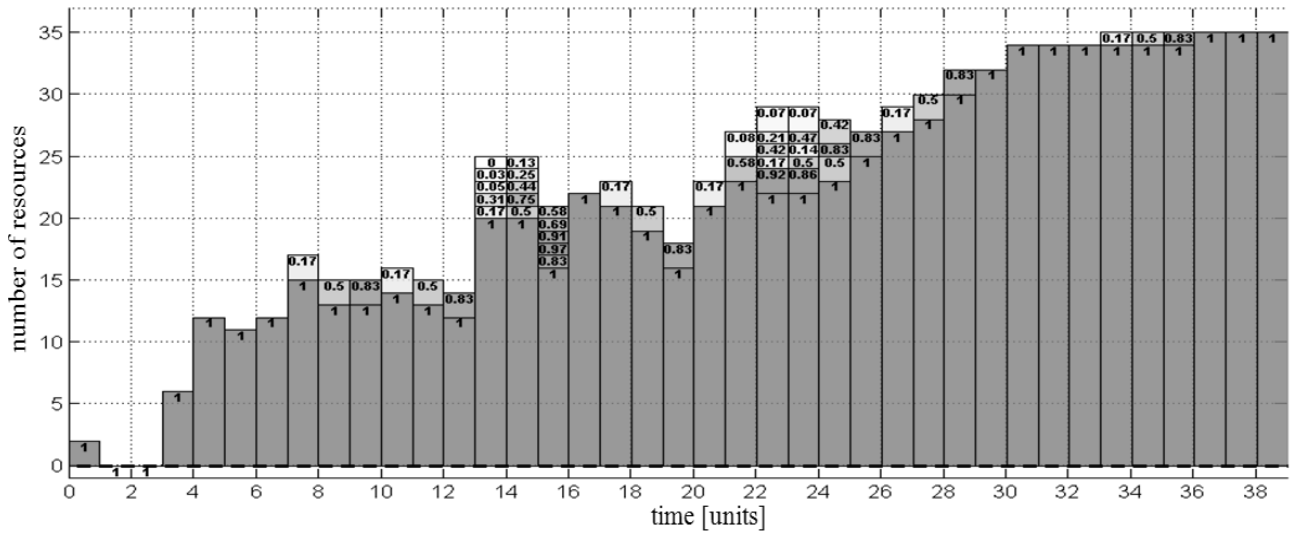

Figure 15. Usage rate of non-renewable resource zn2 *(source: self study)*

Example 4 – „straight"/imprecise variables

Given the following projects portfolio, i.e. the set of projects P = {P_1, P_2, P_3, P_4} as in the Example 3. However, the new, shorter time horizon H = {0, 1,…, 33} is considered.

The problem considered belongs to the class of „straight" ones and reduces to the following question: Does there exist a schedule following constraints assumed on availability of renewable and non-renewable resources and NPV > 0 such that production orders completion time not exceeds the deadline h with the uncertainty threshold DE ≥ 0,7 ?

In the case considered, in 3 seconds, the DST4P^3 package's response was: *Lack of any solutions***.** That means no schedule there exists under assumption of the uncertainty threshold DE ≥ 0,7. In such situation, however there is still a possibility to reformulate the problem considered by assuming greater uncertainty level (less value of DE). In case the increasing of an uncertainty level is not acceptable the decision maker can reformulate the problem statement, e.g. stating it in a reverse way. In such a new formulation the decision maker is looking for the values of a subset of assumed decision variables guaranteeing the makespan of considered projects portfolio will not exceed the deadline h. Such the case is just considered below.

Example 5 – „reverse"/imprecise variables

Given the following projects portfolio, i.e. the set of projects P = {P_1, P_2, P_3, P_4} as in the Example 4. H = {0,1,…,33} is the time horizon considered.

Given the uncertainty threshold value DE ≥ 0,7 limiting uncertainty of constraints specifying projects portfolio. Similarly to the Example 4, the operations times of activities: $O_{1,6}$, $O_{1,10}$, $O_{2,3}$, $O_{2,6}$, $O_{2,8}$, $O_{3,2}$, $O_{3,4}$, $O_{3,7}$, $O_{3,11}$, $O_{4,4}$, $O_{4,9}$, $O_{4,13}$ have an imprecise character. Moreover, let us assume that besides of operation times of the following activates $O_{3,7}$ and $O_{3,11}$ the values of all rest parameters are known. Given is the following relationship linking operation times of activates $O_{3,7}$ and $O_{3,11}$:
$\hat{t}_{3,7} + \hat{t}_{3,8}$ = about 8.

The problem considered belongs to the class of „reverse" ones and reduces to the following question: do there exist such activities operation times guaranteeing production orders completion time not exceeds the deadline h with the uncertainty threshold DE ≥ 0,7 while constraints assumed on availability of renewable and non-renewable resources and NPV > 0 hold?

In such problem formulation the searched solution regards of the values of some decision variables guaranteeing the makespan of considered projects portfolio do exceed the deadline h. So, in the particular case the considered variables are activities $O_{3,7}$ and $O_{3,11}$, and the searched values concerns of activities operation times $\hat{t}_{3,7}, \hat{t}_{3,11}$ and moments of activities $x_{i,j}$ beginning, i.e. the components of the following sequences: $X_1 = (x_{1,1}, \ldots, x_{1,10})$, $X_2 = (x_{2,1}, \ldots, x_{2,12})$, $X_3 = (x_{3,1},\ldots, x_{3,11})$, $X_4 = (x_{4,1},\ldots, x_{4,13})$.

The first admissible solution provided by DST4P^3 (obtained in 15 s) has the following form concerning the

operation times: $\hat{t}_{3,7} = 6$, $\hat{t}_{3,11} =$ "about 3" (see Fig. 16) and the following form concerning the moments of activities start:

$X_1 = (0, 1, 1, 4, 11, 15, 8, 11, 22, 23)$

$X_2 = (0, 3, 10, 10, 13, 15, 19, 18, 23, 25, 25, 29)$

$X_3 = (0, 3, 3, 9, 15, 5, 17, 15, 18, 24, 28)$

$X_4 = (0, 0, 3, 5, 5, 3, 3, 12, 8, 6, 13, 15, 18)$

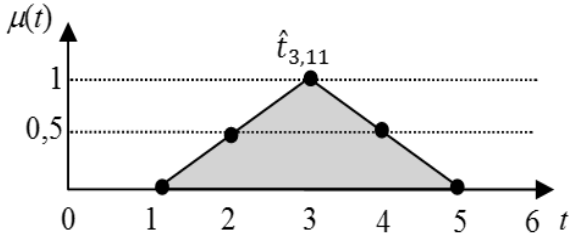

Figure 16. $\hat{t}_{3,11}$ = "about 3" *(source: self study)*

The NPV index value calculated for projects: P_1, P_2, P_3, P_4 follow the requirement NPV > 0, i.e. NPV_{P1} = 0,3649, NPV_{P2} = 2,6024, NPV_{P3} = 1,6014, NPV_{P4} = 0,8165.

The graphical representation of the projects portfolio schedule is show on the Fig. 17. The schedule obtained assumes operation times of activities $O_{3,7}$, $O_{3,11}$ equal to "about 6" and "about 3", respectively, and follows all constrains imposed by an enterprise capacity and projects execution requirements.

Obtained schedule provides the plan for projects portfolio execution, and provides a base for further adjustment aimed at fitting to real live execution [3]. The adjustment process consist in narrowing down the periods of operation times (by changing the beginning and ending moments of activities executions) as to avoid their overlapping, i.e. removing the confusion regarding the cases where an activity's ending exceeds its begging. It that context the schedule fitting leads to a minimal, confusion-free periods of operation times. The illustration of such fitting is shown on Fig. 18 presenting the projects portfolio schedule assuming the uncertainty threshold value DE ≥ 0,5. The new schedule has been obtained from the former one shown in the Fig. 17 under assumption the uncertainty threshold value DE ≥ 0,7.

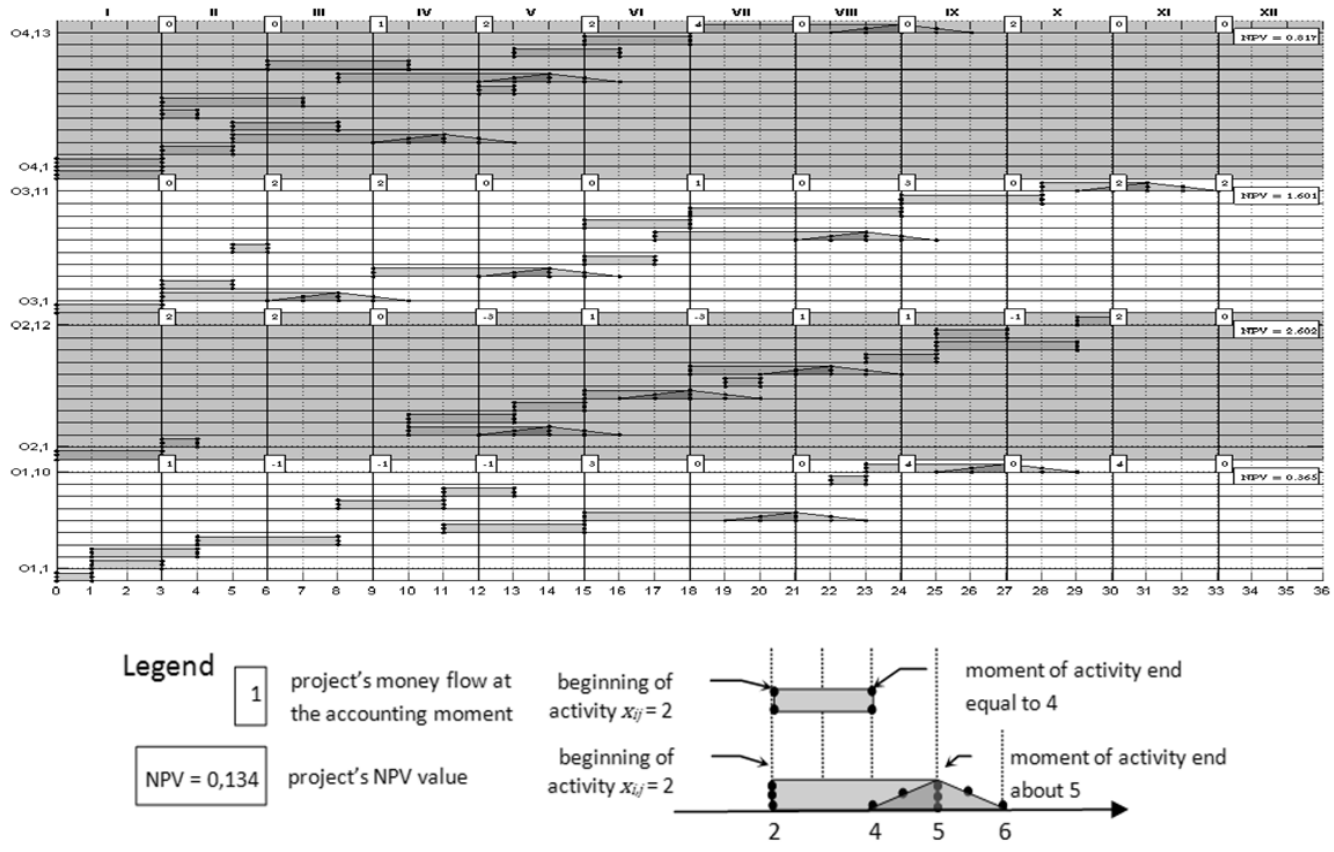

Figure 17. Projects portfolio schedule with the uncertainty threshold ≥ 0,7 *(source: self study)*

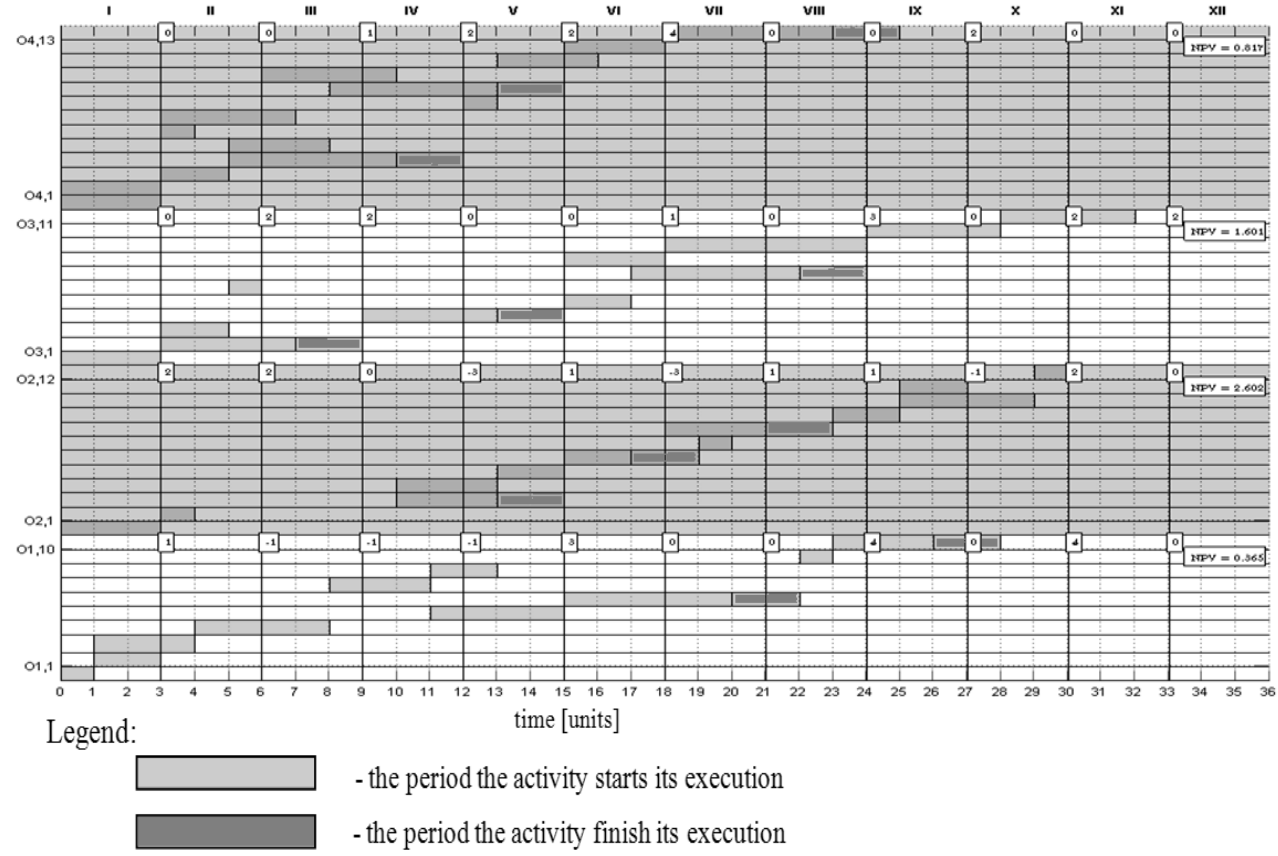

Figure 18. Projects portfolio schedule with the uncertainty threshold $\geq 0{,}5$ *(source: self study)*

5. Concluding remarks

Our approach to an interactive task oriented decision support tools provides the framework allowing one to take into account both: straight and reverse problems formulation. This advantage can be seen as a possibility to response (besides of such standard questions as Is it possible to complete a given set of production orders at a scheduled project deadline?) to the questions like: What variables value guarantee the production orders makespan follows the assumed deadline? Constraint programming paradigm standing behind of the methodology aimed for such tools designing allows to take into account both distinct and imprecise character of the decision variables as well as to consider of multi-criteria decision problems.

The methodology developed is based on the concept of the decision problem reference model [3]. The model considered can be seen as a knowledge base encompassing the structure of a constraint satisfaction problem, where the logic-algebraic method plays a role of inference engine. So, the main idea standing behind of the methodology lies in a way the knowledge base is "adjusted", i.e. adding the conditions guaranteeing the responses to the standard queries there exist as well as conditions guaranteeing the employed them searching strategies can be used in an on-line mode for the real-life size of project planning problems.

Provided multiple examples illustrate a way some arbitrary selected cases can be managed by DST4P^3 package. Its current version is aimed at an interactive projects portfolio prototyping aimed at SMEs where the number of simultaneously considered projects do not exceeds 5 and whole number of activities do not exceeds 80. In that context the approach presented can be considered as a new alternative contribution to project-driven production flow management, and its DSS implementation can be applied in make-to-order manufacturing as well as for prototyping of the virtual organization structures.

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APPENDIX A

Imprecise variables specified by fuzzy sets and determined by convex membership function can be characterized by α - cuts (Piegat, 1999), and then defined by pairs (a1):

$$(A_i, \alpha) \tag{a1}$$

where:

$A_i = \{A_{z_i,1}, A_{z_i,2}, \ldots, A_{z_i,lz}\}$ finite set of so called z - cuts,

$\alpha_{i,j} = \{\alpha_{i,1}, \alpha_{i,2}, \ldots, \alpha_{i,lz}\}$ – is a set $A_{z_i,1}, A_{z_i,2}, \ldots, A_{z_i,la}$ of values corresponding to α - cuts at levels $\alpha_{i,j}$,

lz – a number of z-cuts

and (a2)

$$A_{z_i,k} = [a_{i,k}, b_{i,k}]_N \tag{a2}$$

where:

$a_{i,k}$, $b_{i,k}$ – is the smallest and the highest value of the k-th α - cut, $a_{i,k}, b_{i,k} \in N$.

The z-cut can be seen as a discretized form of the α - cut, i.e. $A_{z_i,k} = A_{\alpha_{i,k}} \cap N$, see Fig. 1a.

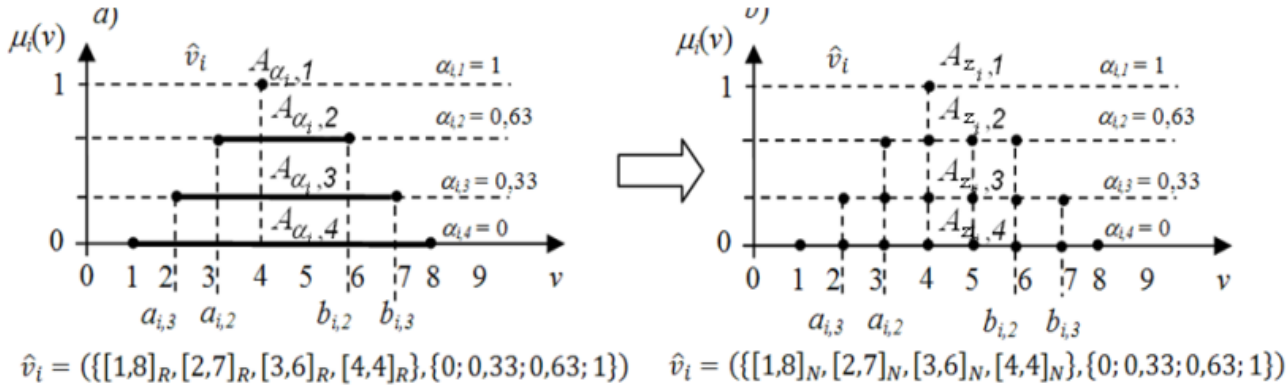

Figure 1a. Fuzzy set $\hat{v}_i$ specified by: a) α - cuts, b) discretized α - cuts, i.e., z-cuts
(source: self study)

Note, that in the assumed specification distinct values are represented by relevant singletons.

Imprecise character of decision variables, e.g., $\hat{x}_{i,j}$, $\hat{t}_{i,j}$, implies imprecise character of employing them constraints, which in turn can be considered as a consequence of implementation of assumed operations. Therefore, consider the set of fuzzy operations: **„$\hat{=}$", „$\hat{<}$", „$\hat{>}$",** encompassing standard algebraic operations such as: $=\neq$, $<$, $>$, $\geq, \leq$. Of course, the considered fuzzy operations linking two fuzzy variables $\hat{v}_i$, $\hat{v}_l$ have to follow the condition (a3):

$$E(\hat{v}_i \hat{<} \hat{v}_l) + E(\hat{v}_i \hat{=} \hat{v}_l) + E(\hat{v}_i \hat{>} \hat{v}_l) = 1 \quad \text{(a3)}$$

where:

E(a) – the fuzzy logic value of the proposition a, $E(a) \in [0,1]$.

In order to define fuzzy operations used for description of the deadlock avoidance conditions (a10) the following auxiliary sets v_i^L, v_i^*, v_i^P and v_l^L, v_l^*, v_l^P are defined as well as the concept of a size of fuzzy variable S_i and the size of subsets S_i^L, S_i^P, S_l^L, S^*, S_i^P of S_i.

For each pair of fuzzy variables $\hat{v}_i$, $\hat{v}_l$ defined by $\{(\mu_i(v), v)\}, \forall v \in K_i$, where: K_i is the domain of the variable $\hat{v}_i$, the following sets can be distinguished: v_i^L, v_i^*, v_i^P i v_l^L, v_l^*, v_l^P. For instance, for the set $\hat{v}_l$ the following subsets can be determined:

v_i^L – the set composed of elements v being less (smaller) than all elements from $\hat{v}_l$,

$v_{i,j}^*$ – the set of elements shared with $\hat{v}_l$,

v_i^P – the set composed of elements v being greater (bigger) than all elements from $\hat{v}_l$.

The sets v_i^L, v_i^*, v_i^P are defined as follows:

$$v_i^L = \{(\mu_i^L(v), v)\}, \forall v \in K_i, \quad \text{(a4)}$$

where:

$$\mu_i^L(v) = \begin{cases} \mu_i(v) - \mu_l(v) \text{ if } \mu_i(v) \geq \mu_i(v), v < w_{min} \\ 0 \quad \text{if } \mu_i(v) < \mu_i(v), v < w_{min} \text{ or } v \geq w_{min} \end{cases}$$

$$w_{min} = \min\{K_w\}, K_w = \{v: v \in K_i, \mu_l(v) = 1\},$$

$$v_i^* = \{(\mu_i^*(v), v)\}, \forall v \in K_i, \quad \text{(a5)}$$

where:

$$\mu_i^*(v) = \min\{\mu_i(v), \mu_l(v)\}$$

$$v_i^P = \{(\mu_i^P(v), v)\}, \forall v \in K_i, \quad \text{(a6)}$$

where:

$$\mu_i^P(v) = \begin{cases} \mu_i(v) - \mu_l(v) \text{ if } \mu_i(v) \geq \mu_i(v), v > w_{max} \\ 0 \quad \text{if } \mu_i(v) < \mu_i(v), v > w_{max} \text{ or } v \leq w_{max} \end{cases}$$

$$w_{max} = \max\{K_w\}, K_w = \{v: v \in K_i, \mu_l(v) = 1\}.$$

Subsets v_l^*, v_l^P corresponding to the fuzzy variable $\hat{v}_l$ are defined in the same way.

To each fuzzy variable $\hat{v}_i$, $\hat{v}_l$ and the corresponding subset v_i^L, v_i^*, v_i^P, v_l^L, v_l^*, v_l^P an associated size value can be determined. For instance, the size value S_i

corresponding to the fuzzy variable v_i, and specified in terms of z-cuts can be defined as (a7):

$$S_i = \sum_{k=1}^{lz} \left\| A_{z_i,k} \right\|, \tag{a7}$$

where:
$\left\| A_{z_i,k} \right\|$ – a number of elements of the set $A_{z_i,k}$.

In the similar way the values S_i^L, S_l^*, S_i^P, S_l^L, S_i^*, S_l^P corresponding to the sets v_i^L, v_i^*, v_i^P, v_l^L, v_l^*, v_l^P are defined.

In the case considered, the equation $S_l^* = S_i^*$ holds for the given v_i^*, v_l^* because the decision variables $\hat{v}_i$, $\hat{v}_l$ belong to the time domain. Therefore, for the sake of simplicity, in further considerations the sizes S_l^*, S_i^* are denoted by the same symbol S^*.

Given fuzzy variables $\hat{v}_i$, $\hat{v}_l$. Consider algebraic-like fuzzy operations following the condition (a3). Fuzzy logic value of the proposition $\hat{v}_i \mathrel{\widehat{=}} \hat{v}_l$ is defined by (a8):

$$E(\hat{v}_i \mathrel{\widehat{=}} \hat{v}_l) = \frac{2S^*}{S_i + S_l} \tag{a8}$$

where:
S_i – the size of $\hat{v}_i$,

S_l – the size of $\hat{v}_l$,

S^* – the size of the common part of sets $\hat{v}_i$, $\hat{v}_l$.

Fuzzy logic value of the proposition $\hat{v}_i \mathrel{\widehat{<}} \hat{v}_l$ is defined by (a9):

$$E(\hat{v}_i \mathrel{\widehat{<}} \hat{v}_l) = \frac{S_i^L + S_l^P}{S_i + S_l} \tag{a9}$$

where:
S_i – the size of $\hat{v}_i$, S_l – the size of $\hat{v}_l$,

S_i^L – the size of v_i^L,

S_l^P – the size of v_i^P.

Fuzzy logic value of the proposition $\hat{v}_i \mathrel{\widehat{>}} \hat{v}_l$ is defined by (a10):

$$E(\hat{v}_i \mathrel{\widehat{>}} \hat{v}_l) = \frac{S_i^P + S_l^L}{S_i + S_l} \tag{a10}$$

Fuzzy logic value of the proposition $\hat{v}_i \mathrel{\widehat{\geq}} \hat{v}_l$ is defined by (a11):

$$E(\hat{v}_i \mathrel{\widehat{\geq}} \hat{v}_l) = \frac{2S^* + S_i^P + S_l^L}{S_j + S_l} \tag{a11}$$

Fuzzy logic value of the proposition $\hat{v}_i \mathrel{\widehat{\leq}} \hat{v}_l$ is defined by (a12):

$$E(\hat{v}_i \mathrel{\widehat{\leq}} \hat{v}_l) = \frac{2S^* + S_i^L + S_l^P}{S_i + S_l} \tag{a12}$$

Formulaes (a8), (a9), (a10), (a11), (a12) allow one to design constraints describing basic relations among two fuzzy variables, such as equality, less than, greater than, less or equal, and greater or equal.

In order to allow one to consider other constraints, e.g., taking into acount distinct variables, the fuzzy operations such as fuzzy addition and fuzzy subtraction have to be employed as well. The relevant operations „$\hat{+}$”, „$\hat{-}$” can be found in [17].

BUSINESS INTELLIGENCE FOR INSURANCE COMPANIES

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Abstract: The article presents current status of IT implementation in Polish insurance companies. Afterwards the man issues connected with information management and proposal of dealing with these issues, due to the implementation of Business Intelligence system, is presented. Definition, structure and scope of application as well as the Business Intelligence system implementation methodology, with a particular consideration for the insurance market character, are presented. Article is summed up with examples of effective Business Intelligence systems implementations in selected insurance companies.

Key words: Business Intelligence, insurance company, analytical data processing, data mining, OLAP, data warehouse.

1. Introduction

Currently there are no insurance companies without implemented IT systems and many of them work with specialized applications with a narrow scope of implementation and without the possibility for quick and easy data exchange. Even though, data gathered at the transactional level is broad and concern most aspects of enterprise's activities, number of used IT solutions causes difficulties in the use of gathered resources. Even in case of an integrated system the data is usually dispersed in many modules and difficult to access in order to gain cross-sectional managerial reviews.

New needs emerge in the field of data migration, integration of existing solutions and a free access to integrated and processed information, which influences the quality and effectiveness of corporate management.

In such case, *Business Intelligence* application tools, which enable the construction of integrated managerial information systems and allow the access to complete, updated and real information, support managerial processes in the enterprise, become essential. The article presents the definition, structure, scope of application and implementation methodology for the *Business Intelligence* systems, which assure effective use of IT resources – gathered and processed by the insurance company.

2. Polish BI market and insurance IT systems

Insurance companies provide insurance products to the market, which take the equitable transfer of the risk of a loss, from one entity to another. Business processes in insurance companies, their unique character and attributes, influence the character of implemented IT solutions. Poland is a relatively large and not entirely occupied market for insurance companies in comparison with highly industrialized countries. During 1999-2004 from 50-70 million of different insurance policies were sold in Poland [7]. The number of active insurance companies has been growing in Poland since 1991. According to the data from the third quarter of 2004 the number was equal to 72 insurance companies and dropped to 69 in the end of 2004. More consolidations took place in 2005 [7]. One of the conditions for further development of the insurance market in Poland is the awareness of the fact that IT solutions grant a better competitive position in the market.

According to the estimations of the DiS analytical company [7] the value of insurance IT market in 2004 was equal to 690 million PLN. Let's take a closer look at the expenses structure in this sector. Approximately 120 software products used in insurance sector were analyzed in the DiS report on insurance IT [7]:

- one third of those programs is used in insurance services,
- integrated insurance systems are 25% of applications presented in the report,
- 11% of presented applications are the Business Intelligence tools,
- ERP packages are the 10% of presented titles,
- remaining products are the self-reliant software titles, which deal with asset management, CRM and e-learning.

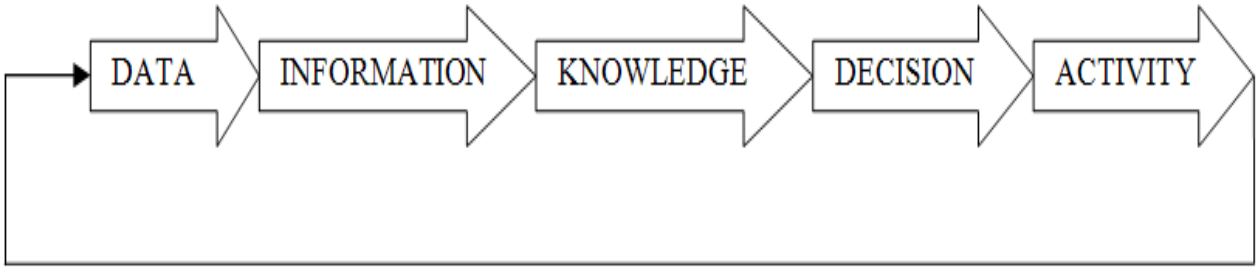

Figure 1. Idea of Business Intelligence System functioning *(source: self study)*

In case of BI and CRM solutions, apart from representation in the form of individual systems, they are a part of inbuilt element of both integrated insurance systems as well as systems supporting insurance agencies. Still the level of BI and CRM solutions usage in Polish insurance companies is relatively low.

The biggest limitation in the usage of the possibilities offered by BI is the lack of automation in the areas of data processing and analysis. Using the improvements provided by BI is lower if the company is using manual data processing.

Together with the development of technology the number of data types and sources increased – today we can speak of not only structured data but also data without a formal structure: text, graphics or multimedia.

Gathered data is usually stored in a way that limits the data usage possibilities when one is using application other than the mother one. On the other hand the data users usually are not aware of the data significance and do not know how it can be used in a useful and purposeful way.

There are cases when different departments do not want to share the data or avoid determining a clear rules and responsibility for data management.

As a result analysts from different departments are preparing reports on the same subjects based on seemingly same data, reaching different results, which, apart from the waste of time, undermines the reliability of such reports.

The article presents practical approach towards system implementation, which enables effective information management and optimal usage of owned data resources, with special attention to the environment of the insurance company.

IT systems supporting managerial processes are currently present in every insurance company. Considerable amount of data is gathered, from every area that the insurance company is interested in, so called transitional data. However the large number of IT solutions is disturbing the data gathering process – even in case of integrated systems the data is dispersed in many modules and not easy to access if one needs to gather data for the sectional managerial report. Therefore implementation of Business Intelligence solution, IT system that transforms transactional data into managerial information understandable, useful and reliable for analysts and managers, becomes justified.

Analytical and forecast preparation aiding applications as well as data mining are the elements of such solution. Business Intelligence becomes an essential tool in insurance company management, which allows diagnosing current and predicting future states.

According to Gartner Group (Gartner Group report, September 1996): „BI solution can be defined as a system that provides technology and set of products allowing access to information necessary to perform business activities and undertake strategic business decisions."

Alexander Miler from Oracle states that [4]: „Business Intelligence is a collection of technology for gathering, storing, sharing and analyzing of information about the enterprise."

According to Andrzej Kicinger from SAS Institute Polska [4]: „Business Intelligence is an integrated corporate informational architecture with interfaces dedicated to different user groups, which allows quick and easy access to credible information in the decision making process".

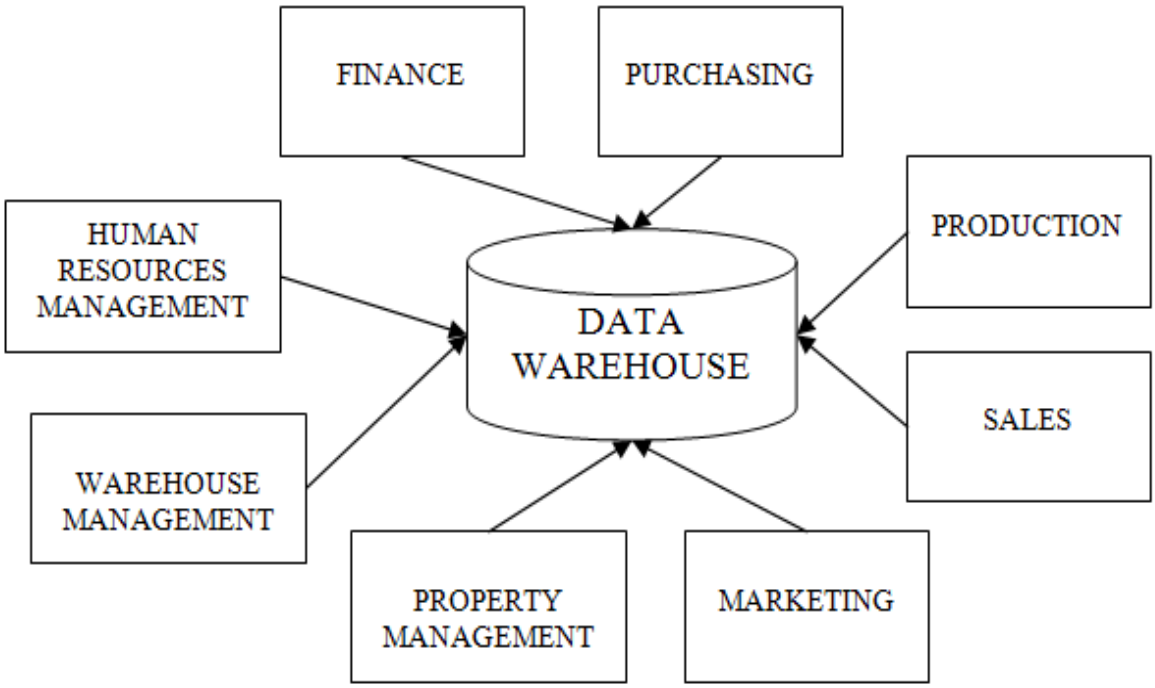

Figure 2. Data sources for Business Intelligence System *(self study)*

3. Definition of Business Intelligence System

Business Intelligence solutions are usually understood as dedicated analytic and reporting software with a graphical user interface, which processes and visualizes information required for managerial decision making processes.

In reality the functioning of managerial information system is based on a structured transformation sequence of data gathered by the enterprise (Fig. 1).

Data provided to the BI system consists of operational data from many different sources, such as: internal resources and customers, resources gathered or purchased from external companies or Internet. This data can be structured or non-structured, stored in many different formats and originate from various applications and transactional systems. Business Intelligence solutions, as an integration element, allow the access to different dispersed data from sources of different structure and format (Fig. 2).

Moreover, BI systems allow the data analysis based on classification, forecasting and simulation methods, what allows gathering new and useful business information. BI systems are especially useful in the following types of analysis:

- financial – researching the income and expenses cost, income statement , profit and loss account with classification of expenses by function, balance and break-even analysis, financial markets analysis and extended controlling system,
- marketing – sales income analysis, sales and margin profitability, sales plan realization, lead time, competition activities analysis, stock prices,
- customers – customer maintaining period, customer profitability, customer relation and activity modelling, customer satisfaction analysis,
- production management – identification of production bottle-necks, order delays, production dynamics study, comparison of production results between departments, plants etc.,
- logistics – quick identification of value chain creation partners,
- salary financial data – specification of salaries according to function, form the company structure perspective, salary specification according to the type of employment, salary surcharges, average salary analysis,
- personal data – employment fluctuation study, employment possibilities according to the division proposed by the Central Statistical Office, employee personal data access.

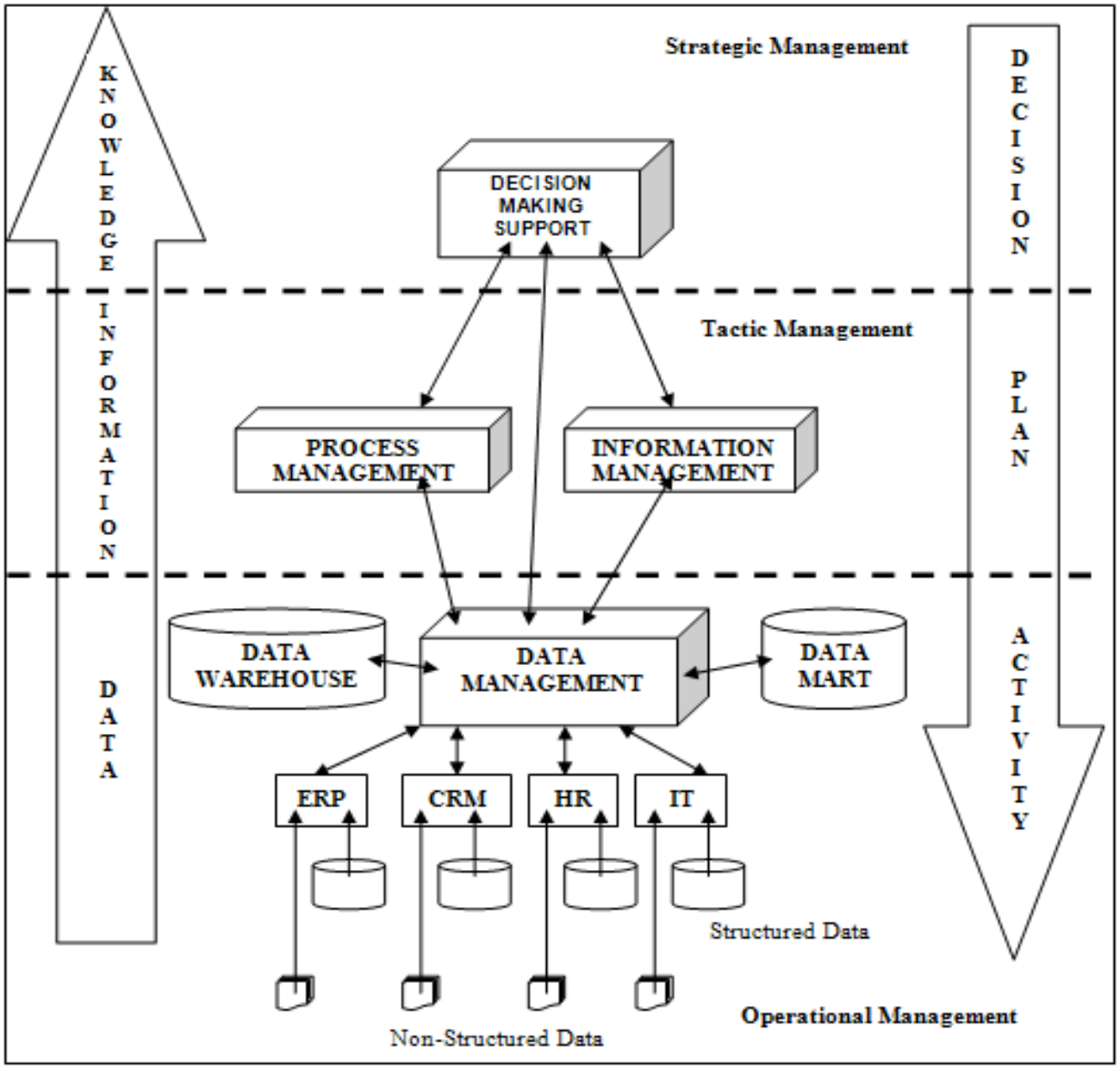

Figure 3. Role of Business Intelligence System in the process of management *(source: [1], pp. 13)*

Analysis results are shared with a variety of tools such as: reporting and analytical systems, informational portals and IT knowledge bases.

Knowledge is the basis for specific managerial decisions. Implementation of taken decisions into business practice assures effective enterprise management and the possibility of gaining competitive advantage in the market.

BI systems are used for gathering, storing and sharing of data as well as information management with the use of various analytical tools. BI systems aim at improvment of information management processes in the strategic, tactical and operational areas (Fig. 3, [10]):

- strategic level – allow precise target setting and tracking of the realization; allow to elaborate different comparison specifications e.g. historical data, profitability of offers, effectiveness of distribution channels etc. as well as performing of development simulations, prediction of future results with set assumptions,
- tactical level – bring basis for decision making in the scope of marketing, sales, finance and capital management; allow to optimize future activities and properly modify organizational, financial and technological aspects of enterprises functioning,

to allow more efficient realization of set strategic targets,
- operational level – used for ad hoc analysis, tend to answer questions connected with current operations of departments, current financial situation, sales, supplier, wholesaler, customer cooperation etc.

Summing up, enterprises use BI systems to aid corporate management, customer relationship optimization, business activities supervision, reporting, planning and decision making aiding. Main strengths of Business Intelligence solutions are:
- shortening of analysis and decision making time,
- simplifying of temporary, collective and other report elaboration with detailed and aggregated data,
- complex reporting systems,
- short response time for user inquiry,
- consolidation, allocation and drilling of data,
- moving the point of balance from data introduction to analysis, exploration of tacit data and detailed interpretation,
- relatively easy localization of significant states in the company e.g. according to cost, delivery on time, customer service etc.,
- providing actual and forecasted data,
- quick and easy system exploration,
- possibility to develop the model and the continuous influence of the user on the system modelling process,
- diversification of data sources.

Problems that can limit BI system implementation are as follows:
- high user training cost,
- requirement of considerable knowledge about analysis techniques (systems generate large amounts of data, therefore the user can have problems with proper interpretation of the data),
- relatively costly and time-consuming implementation,
- high software and hardware requirements,
- vulnerability of the system to poor quality and inconsistency of data, high cost of system administration and development.

Many of these problems can be solved with the proper preparation of BI system implementation – through support of proper implementation methodology and the creation of system, which is essential for and properly used by the company. The following chapter presents the most important areas of the application of managerial information system in insurance companies.

4. BI applications for insurance business

Maintenance of the market position requires from the insurance companies a constant analysis of needs and requirements of the customers as well as adjustment of all business processes in a value chain (Fig. 4) in a way to assure its effective fulfillment.

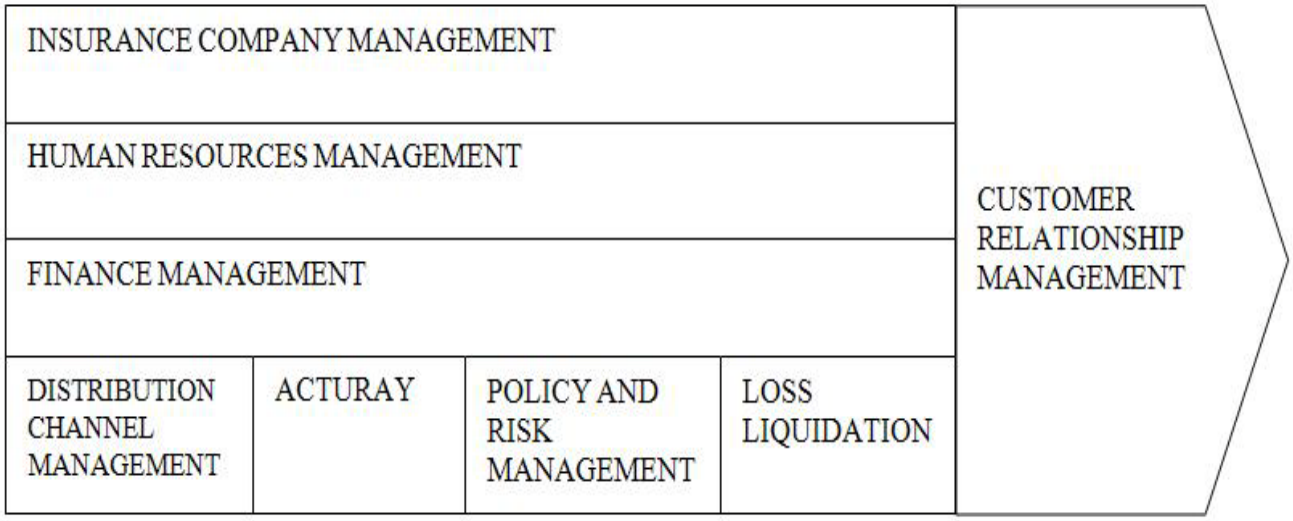

Figure 4. Value chain in an insurance company *(source: [14], pp. 19)*

In order to fulfill these assumptions, insurance companies need to be able to process considerable amount of data (about customers, agents, compensations and policies) into useful business information, which allows proper decision making processes. Business Intelligence tools can greatly improve the goal achievement in different parts of the value chain.

4.1 BI for Customer Relationship Management

Three steps can be distinguished in the insurance company CRM process [13]:

- identification of the most profitable current customers and the ones that will be profitable in the future,
- identification and understanding of customers selected in the previous step and the analysis of their needs,
- cooperation with identified customers in order to fulfil their expectations.

Business Intelligence in particular stages of CRM process is presented in the Fig. 5. It starts with the identification of the most profitable customers in order to improve the quality of cooperation with them. Customer identification includes the determination of customer's profitability and his lifetime value (Fig. 5).

Profitability analysis should provide answer for the following question: why some customers are profitable and other are not? Customer profitability analysis helps to develop new products and adjust the products to the current customer needs and to proper customer segments. Customer lifetime value is an extremely useful measure. For example, data mining tools are used to model customer lifetime value, registering all the factors connected with customer value in the process of all his contacts with the insurance company.

Understanding of the needs of customers selected in the previous stage is based on a multidimensional analysis that includes: segmentation, switching cost and similarity analysis. Segmentation is used to determine customer segments with common characteristics. Such established segments can be treated as separate units and the future cooperation can be adjusted directly to their needs.

Customer segmentation allows preparing offers dedicated to certain groups of customers, what decreases marketing cost and considerably increases its effectiveness. Customers are grouped according to the set of characteristics: personal, demographic, psychological, service cost and profitability of the cooperation. Usually the purchase of an insurance product is a decision with a long time horizon for the customer and if he decides to change the insurance provider, it is highly unlikely that he will come back to the old provider. Therefore maintaining of customers should be the top priority.

Customer resignation causes analysis is the first step to reach the high maintenance of the customers. It requires the analysis of data gathered during the customer contact in different stages of the cooperation.

Customer contact data is connected with other data sources in order to complete the customer resignation analysis.

Created data collections are linked with particular customers and they allow identifying and understanding the causes of their made decisions.

Analysis results can be also helpful in the improvement of particular customer contact stages. Similarities analysis, also known as market-basket analysis, is based on the search of products that present a certain degree of

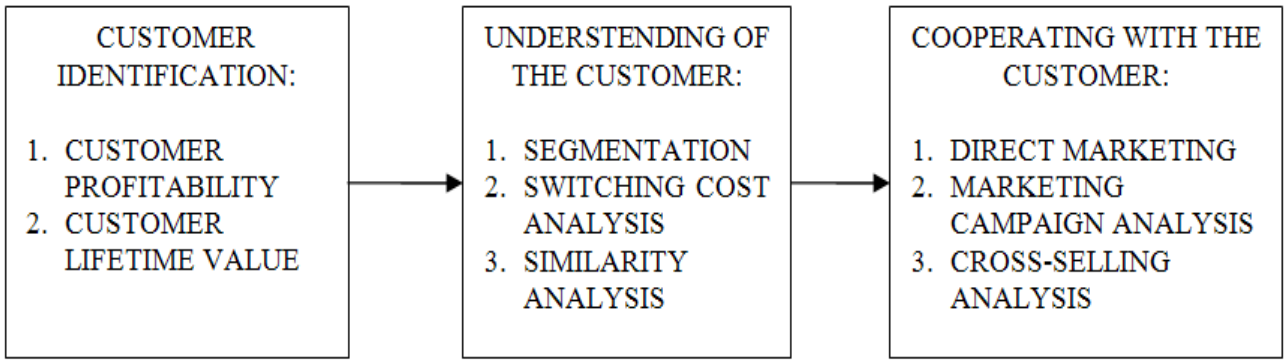

Figure 5. Business Intelligence in CRM *(source:[13], pp. 20)*

similarity. This similarity causes that it is likely for these products to be purchased together. Similar analysis can be performed in relation to customers and their common behavior in the contacts with the insurance company.

Business Intelligence tools, precisely reflecting the activities consumed in the process of customer service can provide useful guidelines in the scope of adjustment of services processes to the needs and requirements of customers. Identification and knowledge of the customer leads to better communication, which is also supported by the analysis connected with the cooperation stage: direct marketing, marketing campaign analysis and cross-selling.

Direct marketing is aimed at a particular customer group – the natural consequence of performed customer segmentation. When customer segments are distinguished, Business Intelligence tools are used to research the products that will be most likely purchased by particular segments. Marketing campaigns directed at particular customer segments are designed on the basis of such information. Marketing campaign analysis is used to analyze the effectiveness of performed marketing and promotional campaigns. Effects of particular campaigns in the scope of the sales of promoted products can be tracked with the use of Business Intelligence tools.

Usually increase in sales of promoted products can cause drop in sales for similar products. Business Intelligence tools also support the identification of such relations. Cross selling is one of the main income sources for the insurance business. Insurance provider needs to highlight this data, which can lead to quick and cost-effective reaching of customers, who probably expect it, with new products. Due to this fact new products can be offered to potential customers during following contact.

4.2 BI for distribution channels management

Traditional distribution channels for the insurance companies are [14]: independent insurance agents, brokers, direct sales agencies and Internet. Business Intelligence tools allow the insurers to gather information from the scope of:

- placement of agents and sales agencies,
- agent network and CRM development,
- distribution channel analysis,
- e-business development.

Placement of agents and sales agencies is based on the geographical analysis of the customer base and depends on the optimal placement of proper agent number and sales agencies in particular localizations. The analysis should include the information about potential customers for new and existing products offered by the insurer.

Agent network and CRM development can also be supported with BI tools. Sales data is analyzed according to the history of activities and sales results of agents and salesmen. Such analysis allows identifying the best agents and salesmen, what helps to prepare the salary strategy. Analysis can be extended with additional aspects of behavior and activities of the sales personnel, what can be used in designing of training programs for agents or salesmen.

Distribution channel analysis concerns the evaluation of activities of particular sales channels. Insurers can compare the results of activities in different channels and perform analysis with different level of detail – to the level of a single agent or product, with the use of Business Intelligence tools. Activities results could be continuously tracked in order to allow the insurer to make right decisions that improve the effectiveness of particular distribution channels.

Special attention should be paid to the evaluation of profitability of particular distribution channels in relation to products sold through and customers gained and serviced through these channels in the process of distribution channel effectiveness evaluation. Servicing cost analysis of particular customer segments in distribution channels and the product sharing cost analysis are the basis for the profitability evaluation and profitability improvement.

Different analysis concerning products and services can be performed on the basis of the data gathered via the Internet. It facilitates the design process of marketing campaigns aimed at the customers purchasing through the Internet, which contribute to the development of e-business. Web log files are another source of useful data that can improve the online operation services. Web log files analysis includes [14]:

- path analysis – analysis of a typical click-stream of the user during website browsing as well as analysis of the most popular pages. Such types of analysis help to optimize the website and its better adjustment to the needs and expectations of the customer,
- link analysis – determines the websites that generate

movement on insurers site through links and references,
- error analysis – reveals the errors encountered by the user in website browsing. It is especially useful in problem solving and increase of the website's quality,
- keyword analysis – analysis of the most popular keywords used in internet browsers that lead to the website of the insurer.

Listed examples indicate that it is another area of the insurance company management, which is strongly supported by Business Intelligence solutions.

4.3 BI for actuary analysis

Actuary function is crucial in the functioning of an insurance company [14]. It concerns risk approximation in relation to the insured property. In case of health and life insurances it concerns the calculation of accident or death probability, basing on various demographic and environmental characteristics. Activities of actuary departments are very complex and have strategic meaning for the insurance company. Actuary uses complex mathematical models, which are used to calculate future insurance premiums and allocation of their part for reinsurance. Business Intelligence tools can also be used in this area [14]:
- risk modelling,
- reinsurance,
- profitability analysis.

Risk modelling, with the use of data mining tools, is based on building of models that identify the insurance risk profiles in different customer segments. These models include risk measures such as average value of the damage, frequency of damage occurrence, loss ratio. Various risk measures can be calculated for a customer segment and afterwards, they should be used for the calculation of a proper insurance premium.

Reinsurance institution takes on itself part of the insurer risk and in return gets part of the insurance premium paid by the customer. In case of damage the reinsurance institution pays out a suitable compensation. Actuary determines proper value of reinsurance, which maximizes the profit with an acceptable level of risk of the insurance company. Data mining tools allow building approximation models, which help to establish the reinsurance level based on the data from paid insurance compensations. Such models identify these policies, which should be assigned for reinsurance, on the basis of experience with similar losses in previous years.

Profitability of existing products can be tracked in relation to various factors such as: product lines, geographical regions, agencies, customer segments, distribution channels etc. It is usually the first step in the prediction of the product life-cycle of new products.

Actuaries build more complex data mining models, which approximate the demand on new products and identify most profitable customer segments for the products, are based on historical profitability analyses. Profitability of insurance products can be determined on the basis of detailed product cost data (cost of activities and resources consumed in processes of elaboration, sales, administration and liquidation of insurance products). Managerial information systems, equipped with dedicated cost models based on activity cost calculation, are the basis for such analysis.

4.4 BI for risk evaluation and policy management

Risk evaluating teams decide whether the risk taken in the process of insuring a customer is acceptable for the company and determine the proper value of insurance premium that will be collected. Business Intelligence tools are supporting such types of analysis [14], taking into consideration such actors as: damageability of the policy, incurred losses and other data that is relevant in case of risk evaluation and policy management. Premium and losses analysis can also be used in such cases, including the support of BI tools.

Insurance premium analysis allows tracking the effectiveness of the premium level in relation to [14]:
- particular products or product lines,
- geographical regions,
- agencies, particular agents of company branches.

Results of such analysis are helpful in the determination of optimal premium value, what can influence the attractiveness of offered insurance products and the competitive position of the company in the market.

Loss analysis is especially helpful for these products or product lines, which have the insurance premium fee lower than the servicing cost. Such kind of loss can be a result of a rough estimation of the preliminary risk or higher than expected cost of servicing and administration of products. Therefore the need of the insurer for constant loss data monitoring is necessary and ob-

vious in order set the cost of recruiting new regaining old customers for products and product lines that are bringing losses. Such kinds of analysis are especially useful in the improvement of profitability level, risk evaluation improvement programs and financial resources protection.

4.5 BI for insurance claims settlement

Quick and efficient dealing with losses creates a basis for good customer relationship management [13, 15]. At the same time the insurer needs to deal with the increasing number of insurance frauds. Insurance frauds are currently very common and most of additional costs for the insurers come from such activities what is, unfortunately, transferred to the customers in the form of increased insurance premium. This draws to a conclusion that quick payoff of compensations contributes to the increase of fraud related cost and the slowly fraud recognition process results in the increased number of such activities leading to increase of insurance premium and decrease of customer satisfaction.

Therefore proper and safe loss liquidation is extremely important for the insurance company. Experience of different institutions show that efficient and long term decrease of fraud and beguilement number is not possible without analytical tools. Business Intelligence analyzes, which can support the activities in the scope of loss liquidation, are [15]:

- loss and compensation analysis,
- fraud detection,
- loss and compensation approximation.

Loss and compensation analysis is one of the basic types of analysis in the scope of BI solutions for insurance companies. They concern the data analysis from the scope of compensations, connected with other data sources, such as policies and risk evaluation. In the first place they are used for the evaluation of loss liquidation process efficiency, which is directly linked to customer satisfaction. Loss and compensation analysis is also helpful in the observation of new trends, which otherwise would be difficult to spot. For example the observation of loss liquidation and sustaining losses trends allows easier optimizing of resources management with simultaneous risk level decrease and increase in resources designated for investments.

Loss and compensation analysis facilitates fraud detection due to detailed analysis of money pay outs according to different factors such as: localization, insurance agent, customer, insurance type.

Fraud detection during loss liquidation can be detected through multilevel analysis of compensation data connected with other internal and external data such as: payment history or risk evaluation. Data mining tools used for the construction of models, which detect fraud and beguilement patterns, are extremely helpful.

Loss and compensation estimation is relatively difficult due to the fact that the real value of losses is unknown before the introduction of new products into the market. In such cases the estimated value must be saved in the form of cash reserves and such funds cannot be used in the process of long-term investments. Therefore the precision of such estimations has a major influence on the profitability of the insurance institution. Multidimensional OLAP analysis can be used for the compensation data analysis according to customer segments or geographical factors in order to estimate future compensations more accurately. In order to reach a better accuracy of such analysis, one can use data mining tools and their advanced compensation estimation models.

4.6 BI for finance management

Financial resources eared from investments used to be the main source of income for insurers in the past and they generally determined the profitability of the insurance company [15]. At the same time the risk evaluation cost was decreasing the profitability of the company. Therefore insurers need to increase the return of investment and decrease the risk evaluation cost and preparation of policies. This requires a direct access to financial data in order to perform the analysis. Many institutions try to improve the financial reporting and decision making, through interfering into financial data in the Financial Data Warehouse (FDW).

Budgeting is an example of another process, which can be supported with the Business Intelligence system. Data warehouses allow performance of analyses that compare cost recorded in the budget to actual cost of promotional campaigns, risk evaluation expenses, provisions etc. Equipping data warehouses with BI tools, based on well-established cost analysis methods (ABC/M) and sharing the analytical models, allow deepening of the OLAP analyzes what allows analyzing cost increase causes in many different aspects.

Moreover the analysis results can be used in budget determination processes for following financial periods. Budgeting based on demand and activities and resources usage effectiveness indicators became possible due to the ABC/M models implemented in the BI solutions. This element is crucial in the improvement process of planning and budgeting quality. Budgeting of various analysis based on the cost models (ABC/M) is useful in control improvement and betted cost allocation.

Property management can be also supported by the managerial information systems. Models based on BI tools can be built in order to measure the level of exposure to risk of the insurer to various risk factors such as: share structure change, instability of stock market etc.

Designed models help to predict the effectiveness of the portfolio in different established economical scenarios as well as the future need of the insurer for working capital.

Financial indicator analysis such as: debt and liquidity indicators can be performed for particular time periods. Ability to provide detail and enclose various related report and analyses, provided mainly by OLAP multifactor analysis, allow simplifying the analysis and making it more intuitive.

Profitability analysis – individual products, product lines, customers and their segments, distribution channels and investment activities are also supported by BI solutions. The main factor of profitability analysis is the direct and throughout analysis of cost taken in customer gaining activities, risk evaluation and policies preparation, which are the main factor of insurance institution overall cost reduction. Activity cost analysis is the basis for cost calculation of those and other processes in the insurance company.

4.7 BI for human resources management

Business Intelligence solutions are especially helpful in human relations management strategy in the overall strategy of the enterprise [15]. They present the integrated picture of the employment and facilitate the employee maintaining schemes, productivity increase and cost reduction. BI application usage in HR departments includes mostly [15]:

- human resources applications and reports,
- workforce allocation analyzes,
- introduction of HR portal,
- training and career path planning.

Reports and analyzes concerning human resources support the integrated data revision concerning employment. Various analyzes can concern migration and staff accomplishments, employee resignation, employee accomplishments and other adjusted to the needs of analysis and reporting. Human resources data can be connected with set employment criteria noted in the insurance business, what allow generating various reports that reveal the employment data in comparison with data from the whole industry.

Analyses that present workforce allocation are based on the introduction of new products into the market. People employed in the sales departments, according to the growing demand, can be allocated in various regions, which have the demand higher and it is likely to grow in the future.

Training and career path planning can also be supported with BI solutions. Detailed data on the competence level of the staff can be stored in a data warehouse. It is useful in competence improvement plan design and effective career path planning for particular employees.

4.8 BI for insurance company management

High management of insurance company has specific requirements towards Business Intelligence [15]. Usually the information management department is responsible for provision of all necessary reports. The department is also responsible for provision of different reports required by various agencies and preparation of information necessary inside and outside of the organization, designated for customers in the form of analyses and reports. Business Intelligence environment is aimed at collection of data from all elements of the value chain, what seems to be the most efficient and reasonable solution for the department.

Reports prepared for the top-management have direct influence on the efficiency and effectiveness of the corporate management. Effectiveness measures such as product or product line profitability as well as customers and distribution channels, total cost of main processes and activities, ROI for investment portfolio etc. can be presented in the reports designated for top-management, which supports the decision making processes.

Moreover mentioned reports provide signals about reaching of alarming level of particular effectiveness measures what triggers performance of corrective actions. The reports are also the basis for external expert and researchers reports.

Insurers are required to provide a number of reports to external agencies, government institutions and branch consortiums. Reports required by law can also be easily generated with Business Intelligence tools.

Customer information system is also one of the elements of managerial information system. Historical compensation data can be essential for the institutional customers, which are offered the employee insurance in case of accidents. Such data might help the customer to identify main trends in accidents and damages in order to start corrective actions to limit such events. Customer information system not only reduces cost connected with damage liquidation, but also significantly improves the preservation of customer-insurer relations.

5. Methodology of building BI System

There are three necessary conditions for successful managerial information system implementation:

- experience and knowledge of the designing and implementation team,
- intensive cooperation between designers and users in the whole design and implementation period,
- use of proper implementation methodology, which includes the process break down into smaller projects.

According to [8] the managerial information system design methodology should consist of six stages divided into particular steps (Fig. 6).

Stage 1 – Justification

Step 1 – Business case assessment

Managerial information system is an extremely complex project, which needs to be carefully prepared and managed. Business Intelligence is not only an IT tool, but also a collection of techniques, business solutions and a number of processes, which should be properly implemented. It is connected with organizational changes, management system and serious IT system structure and architecture changes. This leads to high financial resources consumption and, similar to other major IT implementations, huge investment risk.

Therefore a detailed goal definition and indication of measurable and immeasurable profits of such implementation is necessary.

Questions that need to be asked and issues that need to be solved at this stage are [8]:

- information access:
  - what is the origin of information necessary for decision making?
  - what information is accessible and what information is missing?
  - what is the quality and is the information up-to-date?
- business and finical project aims:
  - what are the business aims for the managerial information system realization? are there Business Intelligence applications functioning in the company and can they help in the realization of established business aims?
  - what financial resources are designated for this endeavour?
- who is responsible for financing of Business Intelligence projects in the company?
- evaluation of the company readiness for the Business Intelligence system implementation:
  - is the company ready for Business Intelligence implementation?
  - was the readiness evaluation performed and what results did it provide?
  - what is missing for the better implementation preparation: purchasing hardware and software, standard implementation or maybe hire new employees?
- risk evaluation:
  - what is the risk connected with the construction of managerial information system?
  - what negative impact will be brought by the cancelling of managerial information system implementation?
- cost evaluation:
  - are the predicted profits exceeding the estimated costs of the project?
  - is the total cost of BI implementation known?
  - does the new hardware need to be purchased?
  - does the computer network need to be modernized?
  - are any new software tools necessary?
  - is a Business Intelligence advisor necessary?

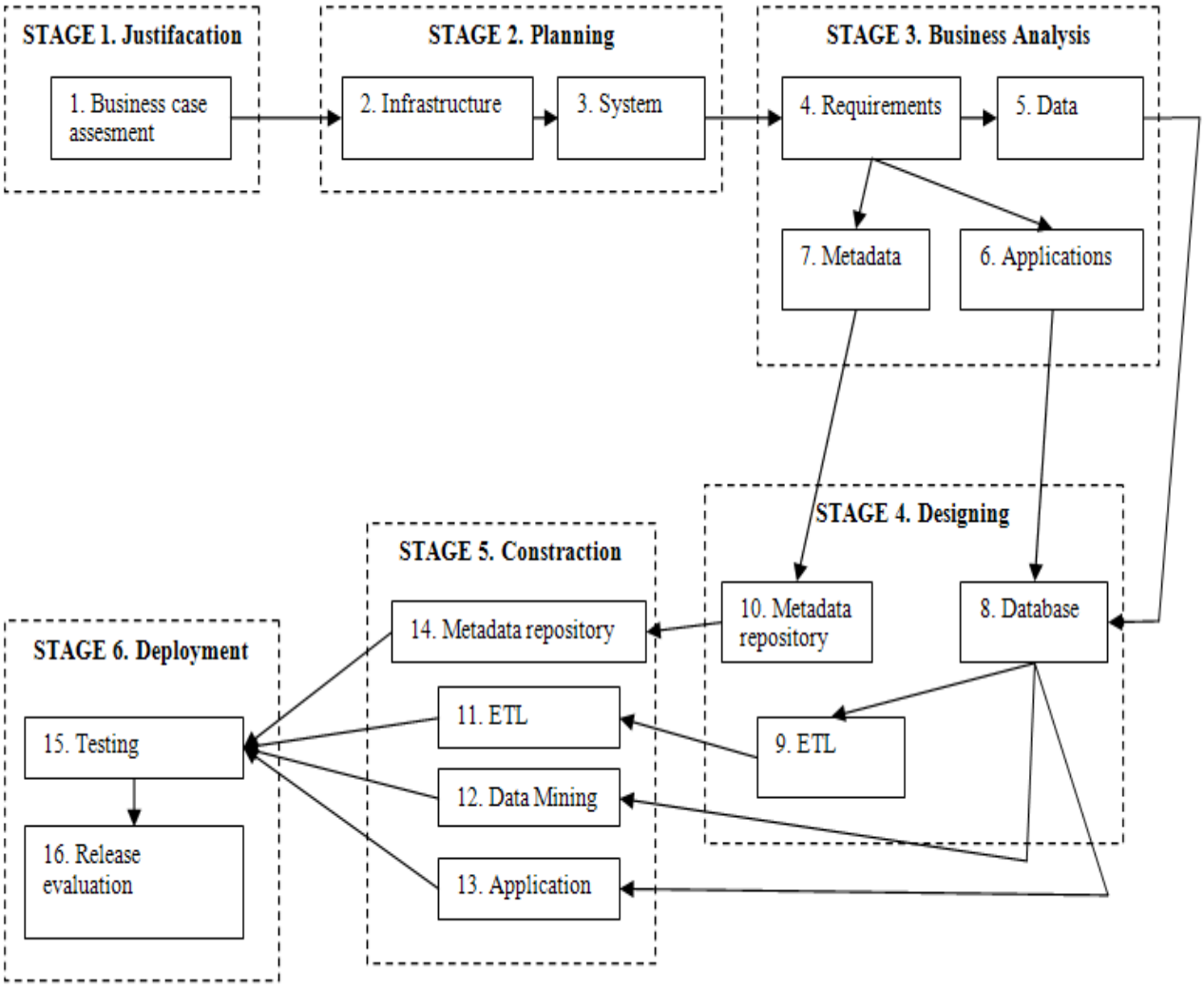

Figure 6. Methodology of building Business Intelligence System *(source: [8], pp. 27)*

- return of investment – calculation of the ROI indicator on the basis of:
  - influence of the implemented system on customer service department performance,
  - influence of the implemented system on customer satisfaction,
  - influence of the implemented system on increase of company's profits,
  - influence of the implemented system on strategic decisions effectiveness,
  - influence of the implemented system on cost reduction,
  - influence of the implemented system on market share increase.

The list above should be treated as an analysis plan, which needs to be performed in the company before the final decision about the implementation of the managerial information system in the company is made. Broad scope of questions allows to determine the **readiness** of the company for the implementation and the possibility of the realization of such investment.

Stage 2 – Planning

Step 2 – Infrastructure design

Whole infrastructure of the enterprise needs to be adjusted to the realization of the project, because managerial information system includes the whole organization. Some of the infrastructure elements remain intact but some of the elements need to be ad-

justed to the project specification. Infrastructure includes two types of components:

- technical infrastructure: hardware, software, network cables, peripherals, database systems, operational systems, network components, metadata repository, user applications etc.,
- non-technical infrastructure: metadata standards, data mining standards, logical database model, methods, textbooks, testing procedures, change control procedures, change management procedures etc.

Step 3 – System design

It is crucial that the project is dynamic and adjusted to the organizational, personal, budget, technological, production with sales and cooperation possibilities of the company. The design needs to be detailed, complete and updates in relation to current changes that emerge in the enterprise.

Stage 3 – Business Analysis

Step 4 – Business requirements analysis

Adjustment of the project, on one hand to the needs and on the other to the organizational and financial possibilities of the company, is one of the most difficult steps in the implementation of managerial information system. It is difficult to limit the natural strive of the user to creation of the system, which would include all necessary information at once and on the other hand, what results from previous experience, such complex implementation are usually unsuccessful.

It is important to divide the managerial information system implementation project into smaller stages, which will service particular subject areas and simultaneously each successive stage of implementation will become a scientific element for both designers and system users.

Step 5 – Source data analysis

Quality of source data is a major challenge for every managerial information system implementation project. Poor quality of data, difficulties with data integration, problems with access to source databases – all of it contributes to the extension of time scheduled for the design stage and usually means the increase of project cost. Some data, which supply the managerial information system decide about its effectiveness and usefulness for the user, therefore proper amount of time and attention needs to be put into this stage by the design and implementation team.

Step 6 – Application prototype

Analytical system, which will function as a part of the project, can be successfully constructed with the method of prototyping, because it is a combination of applications and IT tools. The prototype allows better communication for designers and users as well as speed up to determine the final form and functionality of the analytical system.

Step 7 – Metadata repository analysis

Increase of the umber of IT tools used in the system means the increase of technical data amount in relation to business metadata, which is supported with these tools. Technical metadata need to be mapped on business metadata and next transferred into metadata repository. All metadata, which is introduced and stored in the repository, needs to be documented in logical metadata model. Additionally all metadata requirements need to be accessible to the user through online help function.

Stage 4 – Design

Step 8 – Database design

Source bases for the managerial information system can have various structures, not include multidimensional character and not be adjusted to real informational needs of the system users. Database structure design of the warehouse must include present source data resources, organize it in a manner that fulfills the informational needs of all analytical and reporting modules of the designed system.

Step 9 – ETL process design

Extract-Transform-Load process, also known as data integration process, is the most difficult element of the whole project. It also decides about the success of implementation and business usefulness of the whole project. The following elements influence the complexity level of the process:

- number and quality of data sources supplying the system base,
- source data access,
- informational scope included in the designed system,
- number and complexity degree of prepared reports,
- requirements of system users (number and complexity degree of “ad-hoc” report).

Properly designed and realized ETL process can reveal the previously unknown informational power of the data gathered by the enterprise.

Step 10 – Metadata repository design

If one decides to purchase a ready product the metadata repository design includes only the consideration of these logical features of the model, which are necessary for the realization of designed system, and were not included by the license provider.

In case of dedicated metadata repository, the design must meet the requirements of the logical meta-model, which is based on the relational structure or the object structure.

Stage 5 – Construction

Step 11 – ETL process construction

Many tools available in the market are designed to implement the ETL process. According to the degree of complexity of the cleanup and transformation of data (see Step 5) and the data analysis (see Step 9) different tools can be more or less useful in particular cases. Realization complexity of mentioned processes and determination of specific requirements is necessary in order to select a proper ETL solution.

Step 12 – Application construction

Whenever the application prototype, created in Step 6, fulfills functional system requirements, it is possible to start the work on the development of access and analysis environment development. Constructed application can be only a simple transformation of the prototype into a fully functional system or a much more complex new project based on different IT tools. However in both cases this stage runs simultaneously to the ETL process implementation.

Step 13 – Data mining

Many enterprises, which use the managerial information system, do not fully use the possibilities of their analytical environment and limits the use only to the collection of redefined reports that are most frequently used by the users. Meanwhile the true power of the system and maximal return on investment lies in the hidden data of the enterprise. These are not visible in the standard report group but are possible to gather if one uses such methods of multidimensional analysis like data mining. It is connected with the need to purchase and application of tools dedicated to mining analyses.

Step 14 – Metadata repository construction

If the metadata repository is created for the system, instead of purchase of a ready product, separate taskforce team needs to be established. It is justified, because the repository development project is usually a broad subproject, which needs to consider: strategic goals, development strategy, business and market conditionings, predicted competition activities and many other aspects of enterprise development, which trigger the development of managerial information system, thus developing the metadata repository.

Stage 6 – Deployment

Step 15 – Testing

When the managerial information system application tests are finished it is necessary to start intensive training for all the people involved, which will use the application or metadata system. Trainings include:

- user application servicing,
- maintenance and development of the database,
- scheduling and ETL process start-up,
- database scaling planning and control.

Step 16 – Implementation evaluation

It is crucial to draw conclusions and use the experience gathered in previous stages of its application, in the following stages of the system realization. If a considerable infringement of the budget or the project realization deadline took place, the root-cause should be closely researched so that such mistakes can be avoided in the following stages. Any kind of tools, methods and practices, which were not useful or disturbed the proper realization of the project, should be eliminated before the start of next implementations.

Many stages of the implementation can be performed in parallel, which allows shortening the entire time necessary for the realization of the project. Project realization time is also decreased due to the increasing experience of the design and implementation team. Success and effectiveness of future implementations can be built upon such bases.

Summing up three necessary conditions of successful managerial information system implementation can be listed:

- experience and knowledge of the design and implementation team,
- intensive cooperation of designers and users during the whole period of design and implementation of the project,
- division of the project into smaller subprojects.

Apart from that the managerial information system design needs to be developed during the whole period

of its exploitation and in order to successfully support the enterprise management process it should:

- include the information life cycle: gathering, storing, cleanup, integration and analysis,
- use not only the information management technology, but also the information management policy,
- maintain the high quality of data, safe access to data and clear responsibility rules.

6. Examples of implementations BI in the insurance industry

AIG PTE – example taken from the experience of the IBM Global Services [2]

AIG Universal Retirement Association (AIG PTE) is a part of the American International Group Incorporation (AIG) capital group. The customers of the AIG PTE are the members of the AIG Open Retirement Fund (AIG OFE) managed by AIG PTE. AIG OFE is obligated by law to provide a number of reports to the Polish Financial Supervision Authority. Apart from that AIG PTE, similar to other commercial endeavors, needs to perform a number of analyses and research of different parameters of managed business. Additionally the fund wants to create current reports about the usage of its electronic access channels (IVR, Internet). Obviously the realized similar analyses and reports in these three areas but even within one area it was using different IT tools. It required an IT system that would allow:

- realization of current reporting and analytical functions in a consistent and efficient manner,
- distribution of reports and analyses results in the intranet,
- performing of analyses to the employees with no IT experience (knowledge of SQL or RPG programming languages) in different departments of the company,
- maximal usage of previous experience and software – protection of AIG PTE IT investigation.

AIG Universal Retirement Association decided to entrust the data warehouse and Business Intelligence system implementation to IBM Polska. AIG PTE indicated the business areas, which require the creation of reports and analyses. AIG PTE employees closely cooperated with the implementation team, providing necessary information on AIG PTE data sources. The result of this cooperation three layer system architecture was created:

- data sources: iSeries data server, Lotus format files and data in other formats of relational databases,
- repository layer realized at the iSeries server (SQL Views) and DB2 UDB database version 7.1 (on dual-core xSeries server),
- analytical layer, allowing the performance of multidimensional analyses, realized with the Business Objects software.

IBM Data Warehouse Center was used to manage the process of data flow between the layers of the system as well as metadata management (stored in DB2 UDB database). Creation of most aggregates as well as the loading of, so called, dimensions is performed through a repository. Data loading between layers is performed offline. Analysts use the online system while working in data storages prepared with Business Objects software.

Created system corresponds with the technical requirements of AIG PTE and the whole implementation fulfilled the basic success criteria. It is important that in the creation of the efficient and stable system technologies, known and admired by AIG PTE (IBM iSeries, DB2), were used to full extent. BI system at AIG PTE is the example an optimal use of four technologies to create an efficient and scaled reporting and analysis system. It is a successful combination of the following technologies: IBM DB2 for OS/400, IBM DB2 UDB at xSeries and IBM DataWarehouse Center with Business Objects package.

Allianz Austria – example from the experience of SAS Institute [12]

Allianz Elementar Versicherungs AG (Allianz Austria) provides a wide variety of insurance products that includes life, health, cars and property insurance. The enterprise hires 3000 employees that include direct sales personnel, agents and brokers. Private and enterprise customers are serviced through sales agents spread across the country. Allianz Austria, similarly as many other insurance companies, needs to fight to maintain customers in an extremely competitive market. Currently customer maintenance and profit protection is the highest priority for the company. SAS software provides Allianz Elementar with tools for gathering of knowledge about customers, supports sales activities and protects profits.

Allianz Austria has been using the SAS software, for the business activities support – especially in launching new products to the market and customer relationship

management, for ten years. SAS software is used in analysis and reporting. Using the SAS Enterprise Miner program for the customer segmentation, basket analysis or prediction of customer behavior and preferences is very useful.

Profit Protection Program (PPP) was elaborated in 2003. It focused on the customer recognition and analysis, which are bringing high profit but are likely to change the insurance company (e.g. due to the expiration of the policy). Program assumed investments in such customers in order to keep them in the company so they could provide further profit. SAS Institute became a strategic partner in the realization of the program.

First stage included construction of data warehouse, which gathered and shared the following customer data:

- demographical – age, sex, customer contract data,
- insurance – name and type of the insurance product, value of the insurance premium, insurance period, history of paid premiums,
- trade – distribution channel of the insurance products purchase.

PPP program focused on short-term products and individual customers. First research was based on a 10% of selected customers. Customers, who provide the highest profit and are most likely to change the insurer (due to the expiration of current policy), were selected from the group. The project managed to lower the average quitting pace by 25%. Profit increase of 2% was observed during six months of the research (generated by the observed group of customers).

The possibility of more precise prediction of growth and formulation of profit, which transforms into better enterprise planning, was also of high importance. Due to the high effectiveness of the PPP program, the researched customer group was extended in 2004. Customer Service Department was provided with a list of customers, which were to be treated in a preferred way. Therefore a tool that allows a better control over customer rotation and company's profit was created. Two SAS Institute tools were used for the analysis and reporting: SAS Enterprise Miner and SAS Enterprise Guide.

AXA Insurance - example from the experience of InspireTech Sp. z o.o. [4]

InspireTech Sp. z o.o. together with ABC Data Educational Centre created and implemented a unique Business Intelligence system in Avanssur S.A. - AXA Insurance.

AXA is one of the biggest insurance groups in the world. AXA brand appeared in the Polish market in 2006 and through the acquisition of Winterthur Group it emerged also in Polish insurance and retirement fund market. AXA Group performs its insurance activities in Poland through the following companies:

- AXA Insurance (Avanssur S.A. Polish Division) – offers the full scope of communication insurance,
- AXA Universal Retirement Association,
- AXA Open Retirement Fund – active in Poland since 1998 as a II pillar of Polish retirement system managed by AXA Universal Retirement Association,
- AXA Life Insurance Association - active in Poland since 1994. Leader in Polish insurance market. Providing modern solutions to individual and corporate customers in the scope of: life insurance, protective and health insurance and insurance with capital funds gathering financial resources for future retirement,
- AXA Insurance Company active in Poland since 1995 in the scope of personal and property insurance.

Dedicated solution for Avanssur S.A. was based on two pillars:

- data warehouse,
- reporting system.

Project was based on the Microsoft Solutions Framework methodology. Microsoft Solutions Framework is a technical project approach based on a defined set of rules, models, disciplines, ideas, guidelines and best practices of the Microsoft Corporation. MSF methodology includes:

- foundational principles – main rules that are the basis for the whole structure; includes standard common for all MSF structures,
- models – schematic descriptions of team model and process model project organization,
- disciplines – practical application of specific sets of methods, terms and approaches (e.g. project management, risk management, readiness management),
- key concepts – ideas that support the MSF principles and disciplines and are introduced on the basis of proven practices,

- proven practices - practices, which turned out to be effective in real-life projects and in changing conditions,
- recommendations – optional, but suggested practices and guidelines.

InspireTech Sp. z o.o. constructed data warehouse for Avanssur S.A. with the use of Microsoft SQL Server 2005 64-bit Edition platform and Microsoft Windows Server 2003 Enterprise Edition server platform.

One scaled information repository was created through the integration of heterogeneous data sources.

Second pillar for Avanssur S.A. was based on Reporting Services and extended with individual needs Avanssur S.A with the use of ASP.NET and C# on the Microsoft .NET 2.0 platform.

Samsung Life Insurance - example from the experience of Sybase [11]

Samsung Life is the branch leader in South Korea. Company sells individual and group life insurance through a gigantic network of agencies and over 30 thousand salesmen.

Samsung Life Insurance was in need of an integrated view of its IT system – enterprise was using 10 data storages, which were usually non-compatible and extra data was placed in different locations. The company launched a data warehouse construction project in order to integrate current databases.

Main task was the elaboration of quick, reliable process, which would allow the field users a common data view as well as integration of ten independent collective databases. Samsung Life had three targets of the project:

- increase of the field-workers competences, allowing them to perform their own analyses,
- providing access to highly compatible data with a common viewer,
- shortening of report generation time.

Products from various providers were simultaneously tested, including: NCR, Oracle, IBM and Sybase. Sybase IQ, database designed for data warehouses, was awarded first place due to the speed of inquiry processing and compression ratio. Higher compression ratio results in more disk space and lower cost of mass memory, what in terms of few TB is of significant meaning. If the corporate database was built on the basis of other database type, perhaps a hard drive if 3 – 4 times greater capacity would be required.

With the use of Sybase IQ system the enterprise integrated 8 out of 10 different collective databases and created corporate data warehouse. The company limited the need for disk space and lowered the cost of mass memory due to Sybase IQ system functions — advanced data compression and unique row indexing mechanism.

Sybase solution assures quick data access and minimizes disk space required to record huge data collections. Moreover Samsung Life is prepared for the increase of the amount of data – high efficiency of Sybase IQ system – provides room for development.

Analytical responsibility in the scope of contract status, customer characteristics and people who prepare financial plans etc. was moved from the IT team to particular business teams, which allowed saving resources and increasing the general operational capacity. Field workers in need of greater amounts of data can gain easy access to the data warehouse in order to download current and reliable information from an accessible and usable environment. After the implementation the new system did not cause any business processes delays.

Main benefits reached through the project were:

- considerable increase of the operational capacity of the enterprise,
- easy access to strategic data,
- 25% reduction of disk space in comparison with other data warehouses.

7. Summary

The main task of managerial information systems is the data analysis and provision of high quality information to all management levels. It is a common view that implementation of managerial information system is a success factor for enterprise activities. Demand for such solutions is constantly rising, what enforces easy access to precise and reliable information that support management processes. Another advantage of such solutions is the possibility of use for person in charge, due to its user-friendliness and easy access.

When observing Polish insurance market, one can observe that more insurance companies is using analytical tools and recording systems. Therefore not only ownership and gathering of processed data is important but also proper usage of such data becomes of great significance. Such usage of data is possible after the implementation of managerial information system and the data becomes valuable insurance information.

Identification of the need of using an effective Business Intelligence environment, based on proper architecture, becomes crucial. Therefore it is the first step in the system implementation. Aim of enterprise activities should be the drive to integrated BI environment with the decision making process.

Efficient gathering of required information of all user groups is a significant stage in the creation process of integrated BI system. Ability of precise business targets, which are planned to reach through the use of Business Intelligence as well as full support of the high management for realized projects, is crucial. One of the primary targets of the implementation and Business Intelligence systems' development in insurance companies should be precise and detailed analysis of profitability and preparation of relevant project adjusted to the needs and requirements of the user.

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VALUE MANAGEMENT IN NON-PROFIT ORGANIZATIONS – THE FIRST STEP

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Abstract: This article represents a initial observation on implementing a value management concept for non-profit organizations. Introducing strategic management in non-profit companies is becoming inevitable in order to build up their competitiveness on the non-profit services market. In the first part of this article the key stakeholders of non-profit organizations are identified. The second part is an attempt to present the principal value drivers of non-profit organizations. The groups of key stakeholders that are the most important recipients of the value created by the individual drivers have been assigned to the principal value drivers.

Keywords: value, stakeholders, non-profit, strategic management, value drivers, value management.

1. Introduction

In the last twenty years the number of non-profit organizations has increased enormously; the scope of their activities has broadened as well. Such organizations are involved in almost every aspect of human activity throughout the world. One no longer sees non-profit organizations only engaged in marginal activities of dubious quality. They play an important role in almost every society, assisting in providing health care, in development of education and social well-being [39].

As Drucker [17] notes, forty years ago the very word "management" was treated as something inappropriate by non-profit organizations. It implied "business", with which such organizations had nothing in common. Bogacz-Wojtanowska [7] notes that often, according to many practitioners, the opinion that there is no need to manage non-profit organizations still lingers to the present day. She also writes, however, that when non-profit organizations started to become one of the main socio-political forces in the world in the 1990s how they function and the challenges related to their effective management became highly relevant.

Managing the non-profit organization must and should lead to its s*trategic, market and pro-ecological* orientation. This is an essential requirement for creating its future competitiveness on the non-profit services market. Competitiveness requires non-profit organizations to think strategically and engage in long-term planning, which lead to their opening up to the non-profit services market. They need to learn and create their own visions of the future, becoming in the process more intelligent organizations, serving their environment [44]. The strategy plays a special role in non-profit organization management – it allows for the transformation of actors' intentions, contained in mission plans, into real achievements [16].

In various definitions of management and strategic management, the key goal for the functioning of an enterprise is increasing its value. The value of a company is understood as the sum of benefits for its ownersstockholders or shareholders. All management efforts should therefore focus on maximizing the satisfaction of the owners of the enterprise. The majority of the largest organizations on the Fortune 500 list are managed through value. It is a widely accepted management concept, and one which means that clients return, also inspiring employees to work to their best every day, leaving owners proud and satisfied with their profits [6]. If the concept works so well among business organizations there is no reason why the third sector should not benefit from their positive experience.

The main aim of this article is to make a first step towards transferring the concept to third sector organizations. In adapting value management to the conditions of non-profit organizations one needs to consider the following very important elements: who are the key value stakeholders of the non-profit organizations and what are the key factors influencing the value of the non-profit organization?

The first part [of the article] identifies the key stakeholders of non-profit organizations. Brief literature research was made to identify stakeholders, both in the business sector, as well as among authors writing about the third sector. The second, and the most important part is an attempt to present the principal value drivers in non-profit organizations. Rappaport's (1999) approach to this issue is presented, as well as the ap-

proach of other, Polish, authors. Based on the literature research, the author of the article shows that the factors influencing value are undoubtedly to be found in the organization's resources, mostly among intangible assets. The groups of key stakeholders that are the most important recipients of the value created by individual drivers have been assigned to the principal value drivers. A brief presentation of each of the identified group of drivers focuses on their role in non-profit organizations. Identification of key value drivers is an important activity for each organization, including those from the 3rd sector. Determination of the key value drivers and then, acting from the need to increase their value, should contribute to increasing the efficiency and effectiveness of the activities of non-profit organizations.

2. Stakeholders of non-profit organizations

In the private sector activities aiming at increasing the value of individual enterprises are mostly oriented towards their owners, who are usually their stockholders as well. Stockholders, as people possessing part of the company's assets, are mainly interested in increasing its value, above all by raising its stock price. Only later other stakeholders, such as employees, suppliers, consumers, competitors and other organizations working in the company's environment, are taken into account.

Clarkson [13] describes stakeholders as persons or groups that have, or claim, ownership rights or interests in a corporation and its activities, past, present, or future. He also lists the following groups: employees, shareholders, customers, and others. Primary stakeholder groups are typically comprised of shareholders and investors, employees, customers and suppliers, together with what is defined as the public stakeholder group: the governments and communities that provide infrastructures and markets, whose laws and regulations must be obeyed and to whom taxes and other obligations may be due [13].

In relation to non-profit organizations, the recognized key stakeholders are: government, oversight agencies, private donors and foundations, clients, the media and the public at large [26]. This list may be amended with personnel, beneficiaries, volunteers and members, included by Harris, Mainelli and O'Callaghan [20]. The key to success for a non-profit organization is satisfying key stakeholders' interests, according to their criteria for measuring satisfaction. Key stakeholders are those whose satisfaction is crucial to the generation of sufficient support, legitimacy and the resources sufficient to ensure the organization's viability and effectiveness [10].

It is difficult to talk about owners in the case of non-profit organizations, since despite possessing assets most often they do not issue shares. The organization itself is the owner of the assets, if it is a legal entity. The group of people who are founder members and members of particular organizations are in a sense similar to owners of private companies. Their motivation, however, is not to increase the value of the company, but the extent to which the goals of the organization are reached.

The recipients of the organization's activities form another group of stakeholders. In many cases the recipients are at the same time members of a given organization (e.g. in self-help organizations). However, when the organizations provide services externally the recipients are of course the "purchasers" of those services, or persons and institutions who benefit from the activity of a given non-profit organization. It is also difficult to assume that a change in the value of a donor is of any importance for the beneficiary.

However, the purchasers of services, for example of cultural institutions (sometimes also counted among non-profit organizations) are guests and the public. In this case the value will be of some importance, influencing the decision to visit one or another exhibition, or theatre etc. One should therefore assume that the importance of the value of a non-profit organization for the client will depend on the profile of the organization's activity.

Meanwhile, the value of the organization will undoubtedly be important for all people and institutions that are specific "suppliers" for non-governmental organizations. These include of course current and potential sponsors, donors, benefactors, both institutional and natural persons and local government units, central government bodies, etc. The value of the organization applying for support, as perceived by suppliers, certainly influences the decisions they make. They are much more willing to support institutions that enjoy a good reputation and act efficiently, in other words the ones that have high value and work to increase it.

Employees and volunteers are also extremely important stakeholders. Research shows that non-profit organizations are prone to staffing problems. At the root of the problems is difficulties attracting experienced em-

ployees, who are willing to work either without pay or for nominal pay. If we assume that the number of individuals willing to work on a voluntary basis in a given geographical area is limited we may find that the value of the organization is one of the criteria determining their choice of the organization to which they will devote their time.

One may note a strong affinity between donors and employees in making a decision. Both goals and the ways of achieving them are important for both groups.

The other institutions that may be recipients of non-profit enterprise values include the mass media – moulding public opinion and influencing it. For them the value of our organization is certainly very important, since their task is to inform public opinion elsewhere about the organization's value. This group includes also other third sector organizations – that may both compete and cooperate with each other in realization of the goals. Those institutions cooperating with particular organizations, which may be called "service providers", are an important part of this group of institutions. These include banks, courier companies, postal services, specialized agencies providing services for various types of charity events and others. These companies will tend not be concerned with the value of a non-profit organization since they treat links with the organization on purely business terms.

Identification of the key stakeholders is just the first step in the process of increasing the value of a non-profit organization. The next step is to manage the relationship between the organization and its stakeholders. Managing relationships with primary stakeholders, however, can result in much more than just their continued participation in the firm [22]. Research conducted by Hillman and Keim [22] has proven the hypothesis that *stakeholder management is positively associated with shareholder value creation*. In relation to non-profit organizations, Ospina, Diaz and O'Sullivan [34] point to stakeholders and external relations management as a source of effectiveness.

Balser and McClusky [3] conducted research which suggests that in a community in which information among stakeholder groups is shared, dealing with stakeholders using a consistent rationale based on serving public trust is perceived as a part of effective non-profit organization management. It is also important to consider which value drivers influence its value as perceived by a specific group of stakeholders.

3. Key value drivers of a non-profit organization

Value drivers include each variable influencing the value of the organization. To make use of them it is necessary to group them in order to establish which ones are the strongest value drivers and to make individual employees responsible for the numbers.

The most important drivers are not constant and should be reviewed from time to time. (…) Determining the key value drivers may be difficult, since it requires adopting a new perspective in respect of the processes taking place in the organization. In many cases the reporting system of the enterprise is not able to provide the necessary information [14].

One should stress here that the value of the company is most commonly understood as the financial goal. To measure it, enterprise value methods, based mostly on discounted cashflows, are used. The value of the company is determined by future discounted cashflows, and increases only when the company makes wise capital investments, i.e. when the ROI is higher than the cost of capital [14].

It is similar with value drivers. Operational decisions, that is decisions shaping the structure of products, the level of prices, promotional actions, advertising, distribution and client service, translate in principle into three value drivers: the sales growth rate, operational profit margin and income tax rate. Investment decisions, for example regarding stock levels and any increase in production capability, are reflected in two value drivers: investment in working capital and fixed assets.

The cost of capital as a value driver depends not only on enterprise related risk, but also on financial decisions made by the management or on the problem of establishing the right proportions of indebtedness and own capital as sources of financing, as well as using the appropriate financial instruments. The last value driver, the value growth period, is the number of years estimated by the management when the return on investment rate will exceed capital costs [36].

The Polish authors mention numerous value drivers not of a strictly financial nature. Skoczylas [41], writing about the enterprise evaluation system in the value management environment, quotes a number of "strategic milestones", which she defines as non-monetary ratios, certain data exceeding the annual (budget) planning perspective that have to be reached in order to carry out the key actions or to be able to achieve a cer-

tain status and level of monetary ratios. In other words, these are the key factors determining the value of an enterprise. These are sought in the area of marketing, production and supply, research and development, employment, financing, restructuring and organization and data processing.

Marcinkowska [32] presented an interesting attempt to encapsulate value drivers, providing at the same time financial and non-financial measures of identified variables. According to her, the main drivers are the following: Environment; Human capital, Organizational Culture; Strategy; Clients; Product, Quality, Innovation; Brand; Information and Information Systems; Strategic Alliances, Acquisitions, Mergers; the Natural Environment; Advertising and Public Relations.

Such extensive groups of drivers are justified in the case of commercial enterprises. For a third sector organization, though, they seem over complicated for everyday application and in the majority of cases simply do not correspond with their activity profile. In the literature (e.g. [18]) one can see the attempts to identify value drivers, useful in value management; although these are measures of activity, not value drivers. The authors base their work on the *Balanced Scorecard* methodology, which may be over complicated for the majority of small non-governmental organizations operating in Poland.

Without any doubt one should look for the value drivers among the assets of an organization, most of all among intangible assets. Pike, Roos and Marr [35], based on numerous literature sources, support such a hypothesis. Ashton [2] presents reviews of trends in value creation through human resources and intellectual capital. He examines intangible value and its ties to financial outcomes using the Skandia Business Navigator as a measure. The most important assets, i.e. those giving the organization a competitive edge, are the ones that meet the following four criteria: they should be valuable, rare, inimitable and the organization must be organized to deploy these resources effectively [5].

Most of the resources that meet the criteria are intangible assets. Barney [4] lists the following key assets of an organization: reputation, corporate culture, long-term relationships with suppliers and customers and knowledge assets. One of the first people to introduce the notion of intangible assets was Itami [24]. He singles out: technology, accumulated consumer information, brand name, reputation and corporate culture, arguing that these are the key assets of enterprises and the source of their competitive advantage. Non-governmental organizations in Poland in particular are much less affluent with regard to material assets in comparison to companies from the other two sectors.

The report by the Klon/Jawor Association *Podstawowe fakty o organizacjach pozarządowych* [*Key facts on non-governmental organizations*] shows that 8 out of ten organizations (81%) say that they do not possess any material assets; this is much higher than in 2004, when 71% of the organizations indicated so; also only 3,2% of the organizations had some revenues from assets e.g. from renting premises, equipment, material rights, etc. [19].

Therefore, the intangible assets of non-profit organizations take first place, those that are not reflected in the company's balance sheet and which influence their value substantially.

One cannot disregard the key intangible asset of a company in discussing issues relating to the value of an enterprise. The material assets of the company (machinery, equipment, buildings) can be always replaced with new ones quite easily and fast, requiring only capital. Improving or replacing non-material / intangible assets is much more difficult. Cash is not enough in this case. Such assets as key competences or abilities, organizational culture or the quality of the organization developed in the company over the course of years and by numerous managers. One works on the intangible assets of an enterprise over years, engaging substantial capital. It is very difficult to replace them with new ones, as with a machine.

We should therefore assume that since these assets play such an important role in a modern organization they cannot be disregarded as a component of the value of the whole enterprise. The company's managers should be both aware of the existence of these intangible assets as well as possess the knowledge regarding their current value. The value of intangible assets is becoming one of the management parameters and managers in the non-profit organizations should focus their activities on it.

It seems, therefore, that the most important value drivers of a non-profit organization may be presented in the way shown in Table 1, dividing them into two principal groups. The first relates to the drivers that constitute the organization's assets and the second to drivers that are to a greater extent dependent on processing, transformation, i.e. on managing the assets. Such a division is justifiable if one considers the criterion of susceptibility

Table 1. The key value drivers of a non-governmental organization *(source: self study)*

RESOURCE-RELATED DRIVERS		MANAGEMENT-RELATED DRIVERS	
DRIVER	STAKEHOLDERS – RECIPIENTS OF THE VALUES	DRIVER	STAKEHOLDERS – RECIPIENTS OF THE VALUES
Human capital (employees, members, volunteers)	• recipients • suppliers • cooperating institutions	Quality of the management	• suppliers • employees and volunteers
Leaders	• recipients • suppliers • cooperating institutions • employees and volunteers • members and founding members	Reputation/Image	• suppliers • employees and volunteers • cooperating institutions
Intellectual capital	everybody	Organizational structure	everybody
Key competences	everybody	Action strategies	everybody

of the key value drivers to change. It is usually much more difficult to change the drivers that are part of organization's assets, taking into account the general difficulty in acquiring various assets, in particular for non-profit organizations.

The drivers that can be subject to management are much more easily changeable – for example, by using the right techniques and methods of management. The groups of key stakeholders that are the most important recipients of the values created by individual drivers are assigned to the key value drivers. Defining the most important stakeholders, i.e. the ones whose view of the organization is most influenced by the particular driver, is impossible for some drivers. One should therefore assume that in those cases all the above defined groups are the key stakeholders.

The fact that human capital is one of the basic assets of each organization is no longer controversial. Since the 1970's there have been many studies, tests and management methods that take into account and concentrate on people who provide their work for the particular organization. The word "employees" is not used here on purpose, as in Polish non-governmental organizations only 26% hire paid employees [19], and not only hired employees, but above all volunteers and members involved in work form the foundation of human capital.

The opinion of Krasnodębska, who argues one cannot imagine a well-functioning non-governmental organization without volunteers, is fully shared here. She also argues that voluntary work is one of the characteristic, even constitutive, traits of social organizations [29].

Analyzing the example of Teach for America organization, Hauser also claims that human capital is the most important asset of many organizations, in particular in the non-profit sector. Releasing the full potential of employees requires more than just idealism – effective managers are needed for this as well [21]. Bowman and Ambrosini [8] argue that the source of new use values is the labour performed by organizational members and that a firm's profits can be attributed to this labour.

Drucker (1994) also focuses human capital, claiming that this is the only asset that has the potential to grow. Within human assets, he stresses the role of managers, arguing that they are the ones forming the organization's structure, providing leadership and management spirit, that is the source of the firm's spirit. He com-

pares a firm's goals to management's goals, maintaining that the effectiveness of an enterprise is the effectiveness of its management. Managers are the key assets of an enterprise and the most rare at the same time. Besides managers are employees, who are also an asset of an enterprise – if we view an employee as an asset comparable with other resources (the only difference being he/she is a human capital asset), by analogy we have to think how to use it most effectively.

Marcinkowska [32] notes that all the deliberations on enterprises and their achievements come from deliberations on human achievements – on the possibilities of the human mind and the results of cooperation to achieve a selected goal. We should stress that it is the power of people forming the organization that builds the power of the organization. Most of all it is the knowledge and skills of the employees of an entity (including the management's) and the ability to motivate them to use their competence for the enterprise's development that determine the value of the entity, its competitive standing and market power. The philosophy of human resources management is to acknowledge that employees are one of the most valuable elements of an enterprise.

All the categories of people involved in the past in the organization's activity, i.e. its members, employees and volunteers should be included in the human capital category. Former non-profit organization members are a significant and usable source of valuable assets: knowledge, contacts, time, funds or simply human potential [11].

The activity of numerous non-profit organizations is determined by its leaders. A very strong role of one or several leaders who decide on a majority of issues is noticeable. The MONAR-MARKOT Association and its founder and leader Marek Kotański is a good example.

Monar Association is a non-governmental, apolitical organization, operating throughout Poland. The association deals with a multi-aspect system of preventing drug abuse, homelessness, helping people infected with the HIV virus, people with the AIDS syndrome, terminally ill, lonely and with other threats of social character. In cooperation with the Central Management of Prison Workers it implements programs in penitentiary institutions and offers therapeutic help to people leaving prisons. Throughout Poland Monar carries out loss reduction programs: exchange of needles and syringes, handing out condoms, health counseling, education and information. Its task is to help people in a very difficult life situation. The founder and the guiding spirit of all of the MONAR's activities was Marek Kotański (died in 2002). He was also an unquestioned authority, always present in the mass media, on the issues of drug abuse, people infected with HIV virus and the homeless. His statements built up a social awareness of the above phenomena. After he died, although MONAR continues its activity, it is no longer as visible in the mass media, and its new activities, equally spectacular as in the past, are less visible.

Especially in the context of non-profit organizations one should remember that it is not via the letters, analysis, goals, result measurement systems, etc., that the leaders inspire and motivate employees. Such activities are more connected to the notion of "management" rather than "leadership". People are inspired by exciting visions of the future, with values that the organization can create, lofty ideas – it is a good leaders' task, that is those who want to be leaders of their organizations, to create them.

Activities aimed at increasing the quality of human capital will influence the value of a non-profit organization, especially value perceived by the recipients of activities, by the suppliers and representatives of cooperating institutions.

An investment in the "Leadership" factor will bring about an increase in the value of an organization also in the eyes of the other stakeholders' groups, namely founders, members and the employees themselves of a non-profit institution.

The notion of intellectual capital, defined as the knowledge of employees and management, is directly connected to human resources. Intellectual capital is the resource that stems from relationships between stakeholders and partners, from the organization's ability to innovate and manage change, from its infrastructure and from the knowledge, experience and transferable competencies of its staff [27]. It is a resource of strategic importance, influencing the competitive position and potential of every organization. At the same time it is very difficult to evaluate and very easy to lose. One can distinguish the following layers of knowledge in an organizations: information, news and data; lists, studies, databases or sets of information, news or data; ideas and thoughts (in particular hypothesis, suggestions, concepts); detailed solutions of various types; management style and procedures; methods of action; particular characteristics [12].

One cannot overestimate the role of intellectual capital for a non-profit organization. With the use of the above knowledge layers, one may give specific examples of its indispensability for a fundraising institution. Knowledge, focused in the information, news and data layer, is the source of ideas and thoughts, i.e. those aspects of activity aimed at raising the interest of donors and creating the desired reaction. All the databases, such as address database, will be used by the organization to send invitations to charity events, leaflets encouraging the possibility of tax deductions, etc. Detailed solutions are fundraising methods, such as auctions, works of art, charity balls and others.

The key competences allow the organization to quickly accommodate changes in the environment. Kozińska and Żor [28] describe the competences of an organization as the set of knowledge, skills and inter-structural and interpersonal relations, internal and external that the organization possesses and that are grounded in its culture and its people's behaviour that allows the organization to fulfill tasks and achieve its goals in a manner characteristic of the particular organization.

Competences include the following components: knowledge used in work; experience; abilities and predispositions towards, above all, cooperation in achieving the company's goals, the ability to act professionally; cultural (ethical values) [37].

In recent years, theories arguing that the realization of an organization's goals, including its survival and effective existence, depend on the competence resources it possesses have became very fashionable. All enterprises in a market economy in a constant battle for clients all seek to achieve competitive advantage. The look for the sources of this advantage in the first instance in its environment (new markets, financing sources…). Unfortunately, changes in the environment affect all enterprises competing with each other. Therefore, enterprises increasingly often turn to themselves – to the sources of their competitive advantage within the organization – namely to competences.

It is of particular importance for the specific enterprises active within the third sector. In this sector one seeks ways of resolving social problems, keeping up with market principles and helping the weakest at the same time. The concept outlined by Burton Weisbrod is one of the most important economic concepts explaining the existence of social organizations. In the specialized literature it is known as public goods theory, or the market failure/government failure theory [30]. Generally speaking, social organizations take up that area of economy where the market mechanism turns out to be imperfect. Therefore, they have an extremely responsible task to fulfill thanks to the key competences they possess and develop [40].

Key competences and intellectual capital are the value drivers that are of interest for practically all the organization's stakeholders. It is the knowledge and skills of employees and leaders that the effectiveness of the activities undertaken by the organization depends upon. One does not need to prove that the greater the employees' experience and the better the ideas of leaders, the better the programs implemented by the organization and the better its financing will be.

Another area that brings the possibility of identifying intangible components of an enterprise is the quality of management.

It has been proven many times that if one compares enterprises from the same sector with similar resources and market position, the factor that most accurately explains the differences in results achieved is the way enterprises are managed. Why is it so that barely known organizations develop dynamically to become the largest in their sector while others, previously with a good name, fall into decline and are taken over by others or even go bankrupt? The factor that usually differentiates them is the method of management, in fact the quality of the management, which is becoming the key issue.

Although the quality of management has not been explicitly defined in the literature it is an important, and still open, problem of theory and practice in change management in enterprises and institutions. The quality of methods and tools used by managers determines the effectiveness of decisions vital for the market position of the companies and the atmosphere among employees. Therefore, measures of the effectiveness of an organization's management in the changing market environment are widely sought after [38].

Sajkiewicz [38] gives a several indicators of the quality of a company's management: structures to directly contact clients; conceptuality of management; open communication systems; cooperation in problem solving; constant education; leadership roles in improving the organization; the organization's culture strategy, with its ethical content; orienting processes towards the clients; modern management methods; computer networks for internal and external communication; decentralization of power and flexibility of the structures; a broad spectrum of incentive instruments; compe-

tences in line with the requirements and rational division of labor.

It seems that this area is one that should be developed in non-profit organizations, in particular Polish ones. One of the common problems of non-governmental organizations is resolving the dilemma of finding a happy medium between modern management of the organization and potential loss of flexibility, innovation and the spirit of cooperation and abandoning its mission.

Also in Poland the problem is becoming increasingly important. The main reason for this is withdrawal of foreign funds from activity in Poland. The possibility of using European Union funding has not so far brought any great effect (the above quoted study [19] shows, that as few as 4.5% of the organizations have used this source of financing in the last four years).

Another reason for the growing need to apply modern management techniques is the growing expectations of donors, both public and private. Increasingly often they require the sponsored organization to use measures of effectiveness and results of its activity [7]. These indices can be increased through more effective management.

Why do donors far more willingly respond to appeals of certain non-profit organizations, at the same time ignoring the applications and requests of others, with similar ideology? Why, with a choice of several foundations with identical goals, e.g. helping ill children, do they extend their support to this one and not another? These questions become quite simple when we pay attention to the organizations that tend to be preferred by donors.

It turns out that they are usually e.g. widely known foundations, with relatively long history and having a good "reputation". In the enterprises sector, this mysterious reputation attracts purchasers like a magnet, as a result clients, having a choice between identical products of two different companies, usually choose the merchandise of a well known company, even paying a higher price. As a result, the client pays for the reputation of the merchandise, as the difference in the price reflects this intangible value purchased by him/her.

In the literature one can find many notions with a similar meaning. These are: brand, image, reputation, goodwill.

Goodwill is explained, for example as: the value of the enterprise in inventory, reputation and connections [43], commercial privileges of the company, being the outcome of a thriving enterprise [23].

Dowling [15] presents an interesting argument to support the hypothesis that reputation has a direct influence on the value of an enterprise. The two principal approaches to goodwill valuation that are widely accepted in the academic literature and in the best accounting practice examines Taliento [43].

The image of a non-profit organization may be viewed as an aspect of competitiveness. Not only when one competes for donors, but also for other resources available on the market. The above mentioned human resources spring to mind here. When the number of volunteers willing to work is limited in a particular local area it is, among other things, the image of the organization that will influence their choice of foundation or association and the activity in which they choose to participate.

On the other hand, the negligence of a nongovernmental organization to inform the environment (...) may result in loss of trust and social support [25]. It is due to its extremely highly [valued] image – measured by the knowledge of the organization and trust of Poles for the institution [33] - Wielka Orkiestra Świątecznej Pomocy[2] (The Great Christmas Charity Orchestra) is one of the leaders among non-profit organizations in the category of funds raised.

"Wielka Orkiestra Świątecznej Pomocy" is the largest and most prosperous charity organization in Poland. Its objectives, included in the status document, are saving children's lives, health promotion and education in the field of preventive treatment. Between 1993 and 2006 The charity has collected and spent over $65 mln on saving lives. Besides humanitarian work, it is also a powerful medium spreading an ideology of kindness, friendship, tolerance, and openness.

Therefore, image, as value drivers mainly influence donors, sponsors and other institutions, provides funds for non-profit organizations.

Another value driver of an organization, part of the group susceptible to management, is organizational structure. Organization is not a goal in itself, it is a means to an end, which is achievements and business results. Organizational structure is an indispensable element, a flawed structure may substantially lower the productivity of a business and even destroy it [16]. Each, even the smallest non-profit organization, must have a certain organizational structure. Often the exis-

tence of the structure is forced by e.g. the statute of an organization, where at the least a Management Board must be appointed. Associations have frequently, besides the Management Board, also a Presiding Board, an Audit Committee, Accounting, then Branches, etc. Fundraising sections or sections implementation individual statute objectives may be set. It is worth quoting the main determinants regarding non-governmental organization structures provided by Bogacz-Wojanowska [7], quoted by Wilson [45]:

- size – in the case of small organizations there is no need to split tasks and as a consequence to differentiate [organizational sections]; when the organization grows, it starts to feel such a need, since everybody cannot all the time deal with everything. There are groups or people assigned, responsible for the individual objectives of the organization,
- technology (physical objects and tools, equipment, also knowledge),
- the environment of the organization – its nature also conditions the size of differentiation and integration of non-governmental organizations,
- a stable environment creates favourable conditions for bureaucratic structures, or structures of high vertical differentiation, while a turbulent and unstable environment requires certain adhocracy (temporariness), decentralized structures,
- age of the organization – in the course of years organizations change their social structures,
- financial dependency – the more organizations depend on one, external, source of financing, the more centralized their structure will be,
- strategies – a type of realized strategy of action obliges the creation of specific organizational structures.

Organizational structure seems to be mostly responsible for the relevant flow of information in each organization. A clear hierarchy structure, clarity of official relations translates into quick and efficient and multi-direction flow of information resources. Therefore, it influences the efficiency of actions and therefore any improvements in the organizational structure will increase the value of non-profit organization in the eyes of all groups of stakeholders.

The last of the main value drivers of a non-profit organization one should pay attention to are strategies. This notion should be understood as specific ways to achieve the organization's objectives, together with the resources necessary to achieve them. At the least, we can talk about:

- product strategies – in the case of a non-profit organization these are usually services strategies, aimed at maximizing their quality,
- communication strategies – or methods of informing broadly understood environment/public about its mission, activities, values, etc.,
- fundraising strategies - or activities aiming at providing the organization with the necessary financial means, in connection with specific activities, but also for everyday operations,
- personnel strategies – directed at increasing the quality of human capital.

From a more general point of view regarding the choice of a development path of a given organization we may use the classification of strategies that proposes four variants of activities [1]: market penetration strategy; market development strategy; product development strategy; diversification strategy.

The relationship between the strategy and the value of the organization has been subject to many studies. Lubatkin and Chatterjee [31], among others, examine the stability of the relationship between strategy and shareholder value; Bowman and Ambrosini [8] consider the role of strategy in the context of the value creation process.

It seems that non-profit organizations may use almost all of the above strategies. The activity of Stowarzyszenie Przymierza Rodzin (the Families Alliance Association) is an example of applying most of them:

Stowarzyszenie Przymierze Rodzin is an all-Poland non-profit organization operating since 1983. The work of the alliance is carried out mostly among peer groups of children and young people, parents' groups and families groups, run in the Local Families Alliance Centers at parishes. Currently, about 20 centers are active, grouping about 1500 people. The children and young people's groups (about 500 persons in 20 groups) are run to a large extent according to the scouting method.

The objective of the educational program is the spiritual, intellectual and physical development of children. The tutors are young people, mostly students, and their helpers are chosen from the upper high school. All the tutorial staff (about 80 people in the whole association) work on a volunteer basis. In order to increase their tutorial abilities, courses, training sessions and seminars are organized.

There are about 50 young people attending the courses for tutors and helpers each year. Another objective of the alliance's activity is educational and cultural activity. Currently the alliance runs three primary schools, three lower secondary schools, two general education upper secondary schools, one college, two youth community centers and one kindergarten.

The association uses diversification, placing its activities in various areas (education – running schools and at the same time supporting youth community centres and simultaneously supporting and educating activity in local centers associated with parishes). It uses a market development strategy (starting educational activities at primary schools, then broadening it to kindergartens and colleges and opening new primary and lower secondary schools) and finally the product development strategy (besides concentrating on education in primary school, it also organizes summer trips, youth groups, etc.).

In the context of value management the process of working out the strategy, especially the means used for its evaluation, has to be directed at maximizing value.

The strategy should above all include an explanation of how the entity intends to gain an advantage over other entities, which would lead to increasing its value. Such an explanation should be grounded in full market analysis, analysis of other organizations active on the market and current advantages and the possibilities of the entity. The strategy should also include the value management elements:

- interpretation of the strategy evaluation results and assessment of the main assumptions that have influenced its value,
- measuring the value of rejected strategies and the reasons for rejecting them,
- establishing the need for resources,
- summary of predicted results of strategic plans, in particular including forecasts regarding the main value drivers,
- analysis of several different scenarios to help foresee dangers or new possibilities and their influence on strategies implementation [14].

4. Conclusion and future research

An objective of presentation of the key value drivers of non-profit organizations was above all aimed at drawing attention of organizations to the fact that it is not only human resources and reputation that are the main success factors. The presented classification does not aspire to be comprehensive and exhaustive. The line between separate drivers are certainly also fluid. For example, the notions of intellectual capital and key competences interpenetrate in a certain manner.

A well organized structure certainly depends on the quality of its management, which in turn depends on the leaders of the organization. However, identification of a larger number of value drivers should help to increase the value and help the non-profit organization in succeeding. The increase of its value may be considered the measure of success of a particular non-profit organization. In no way does it contradict other, specific, goals and missions, formulated by third sector entities.

We should only assume that an activity should be undertaken when it increases the value of the organization in the perception of at least one of the stakeholder groups listed first above. In such a way, reaching every goal, be it training for the unemployed, the purchase of medical equipment or securing workplaces for handicapped people, will increase the value of the non-profit organization. At the same time, awareness of the existence of a higher purpose or increasing value will help to focus not only on short-term goals but will help non-profit organizations' to gain in a long-term, strategic way.

The aim of building up value for stakeholders, presented to the environment in an appropriate manner, should also help raise funds and convince sponsors and donors that these are the organizations worthy of support. It also allows organizations to build long-term relationships between donors and the organization, by informing them in an open and clear manner about the influence of individual activities on the increase in the value of the organization they sponsor. Therefore, value becomes a measure of the effectiveness and efficiency of activity, which may be extremely helpful in day-to-day operations of each non-profit organization.

Future research may concentrate on other stages of value management and on working out the concept of their implementation in non-profit organizations. The value management process consists in principle of three stages [36]. The first of them – gaining involvement - aims at attracting all the participants of the organization: its leaders, members, employees and volunteers to the value management concept. They should be convinced

that an increase in value is the main and universal purpose of activity.

The second stage is assessment of value. After the key value drivers have been identified they should be evaluated and their value measured. Then the strategic and operational planning process takes place, or the strategies that will lead to achieving the organization's goals and respective detailed action plans are created. All of that should be done in parallel with training sessions on creating value for stakeholders. The result of this stage is the list of key value drivers, the result of the value assessment and operational strategies and plans.

The stage known as instilling principles is directed at keeping the introduced changes. The result of this will be clearly established result indexes, both financial and organizational, and a compensation (motivation) system correlating with any increase in value. It requires definition of the role of individual sections in the organizations in increasing value and the measure of the results of the organization and compensation systems. Also at this stage training sessions, concentrating on focusing attention of each one of them on their individual roles in increasing value, are necessary.

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MANAGEMENT EFFICIENCY

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Abstract: Modern management process may be viewed as one constant series of decision making and creation of conditions for effective decision realization. In the process of organizing it is important to verify the organization effectiveness and implement corrections in order to maintain or increase this effectiveness. For the purpose of situation diagnosis and improvement of organization's results, the three-efficiency-levels approach is used (organization level, process level, workstation level). Degree of decision effectiveness (efficiency) will depend on rationality of the problem solving process. Therefore, it is necessary to determine the primary and supporting goals as well as strategies for their realization and to take care of the quality of organization's internal activities, which includes full readiness for cooperation and flexibility towards changes.

Key words: Modern management, production management system, organization effectiveness, management efficiency, economic efficiency, managerial work improving methods, performance, productivity.

1. Introduction

This article is a continuation of its authors' considerations included in two previous articles [23, 34] related to company logistics and production management.

In the first of those articles, when describing chosen aspects of system concept of logistics from the efficiency point of view, the authors mentioned a method of affecting efficiency in a logistics system and presented five different relation variants (initial outlay, results) referring to the shape the efficiency formula takes.

Also the authors mentioned shaping of logistics system efficiency from the view of assumptions and phases of logistics development [23].

In the second article, on the other hand, the modern production management systems were compared with regard to utilitarian efficiency [34].

Visibly, the efficiency issue was signalized in both mentioned articles, and its broader description will be the subject of this article. As it is hard to propose a single logical construct of management efficiency (effectiveness, productivity) to the reader, the broad issue was narrowed down by the authors to some key areas.

2. Research problems

In the presented paper, the authors concentrate on a few important directions of management efficiency research, including:

- different approach to the essence of efficiency (effectiveness), way of its presentation and measurement,
- division of efficiency into: economic, organizational and managerial ones,
- essence of increasing of organization efficiency;
- determining the efficiency in processes of: planning, decision-making, organizing, coordinating, motivating and controlling,
- efficiency problems concerning human resources management process, especially with regard to: recruitment, selection, training and efficiency management system,
- gathering knowledge on the efficiency of management style and time management,
- methods of improving managerial work and increasing organization efficiency.

Plan of resolving the above mentioned issues will be based on identification of four key problems.

First problem concerns defining efficiency as a unit of measurement of productivity: if we compare two mines with similar manpower, extracting the same type of coal in the same environmental conditions, with use of similar type of equipment, then the mine which extracts more coal is viewed to be more efficient.

Second problem concerns so called managerial efficiency, which refers to effectiveness of management as opposed to the effectiveness of the whole production unit.

Third problem is the degree to which a given firm should achieve the highest results in a particular, specific environment that surrounds it.

Fourth problem is the way of efficiency evaluation in the sense of the rate of profit. While from the point of view of an entrepreneur the highest capital efficiency is achieved when the rate of profit is maximized, from the society's point of view the most effective allocation of resources may be achieved i.e. when the rate of profit is minimal.

In works devoted to issues such as organization or management, the term efficiency is used in the same meaning as effectiveness or performance. P. F. Drucker used to say efficiency means kind of a habit. It is a matter of certain set of activities, which can always be trained. Later on, they will become a habit, which we learn by practicing and once again practicing. This is how competences are formed.

Efficiency, according to P. F. Drucker, is the key element of human and organizational development. It leads to self-fulfillment and allows a modern society to survive; it is the degree of target fulfillment [6, p. 182].

Efficiency is also, according to this author, the degree of realization of a goal. An extremely important problem in the activity of every entity with regard to this matter is, therefore, proper definition of goal as well as means for its realization.

Obtaining a positive result of actions should be accompanied by: precise identification and determination of the need for introduction of changes; planning and carrying out of a project, which serves the purpose of fulfillment of a certain need; involvement of the whole staff, who should be aware that effects of activity are massively determined by work quality, which, therefore, should be constantly improved, in order to result in an increase of resources management efficiency (including increase of profitability); maintaining pace and direction of changes, which is to help to fulfill a given need; constant improvement of actions in accordance with the Deming circle [28, p. 211].

3. Basic concepts

Organizational efficiency is not an unambiguous term. The literature presents various approaches to the essence of efficiency, way of its implementation and measurement. Also, many similar terms are used, such as: effectiveness, performance, productivity, economy [3, p. 103].

On the basis of professional literature from the scope of economics, economics of work, organization and management or social psychology, it can be stated that in the last 120 years there was a slow but systematic evolution of content and denotation of the term efficiency going on: "from a narrow technical and economic to a humanistic and ecological one" [7, p. 149].

Problem of efficiency has been discussed in Polish literature from the field of organization and directing with various regularity for the last 40 or so years. [31, p. 14-15].

The works concerning problems of organization and management use the term efficiency in the same meaning as effectiveness or performance.

Efficiency is the key element for human and organizational development. It leads to self-fulfillment and allows a modern society to survive; it is the degree of target fulfillment [5, p. 182].

Problem of efficiency cannot be looked at without referring to means and possibilities of its measurement. Issue of measuring efficiency is extremely important, while only then can any area or a whole company be managed, when the phenomena and processes can be measured and analyzed, with the use of even such concepts as time or costs. When speaking of efficiency, it is necessary to consider way of its evaluation. Efficiency is often measured by profitability, and the most effective allocation of resources is always made with micro and macro-scale interests in mind [28, p. 194].

Important problem in processes of efficiency measurement is the proper choice of methods. In this area, i.e. discount methods can be used, which allow evaluation of efficiency of developmental projects [5].

From the point of view of cybernetics, the scope of ex post activity efficiency concept refers to a certain relation between the obtained effects and the initial outlay needed for their realization. Ex ante activity efficiency,

on the other hand, refers to the relation between the target and the anticipated means for its realization [5, p. 151].

Recently, two main approaches to efficiency, goal-oriented one and system one, are underlined. The goal-oriented approach assumes that organizations are established in order to achieve the undertaken goals. The system approach, on the other hand, that rarely are there all the resources in the surrounding. The meaning of purposefulness as a characteristic of an organization, which is a natural system resembling living organism, is underlined. Both these approaches, according to A. Kister, differ profoundly starting from basic assumptions, through the view on the essence of evaluation efficiency and stage-character, evaluation criteria, ending with efficiency measurement [12, p. 4].

"In general, productivity informs us how many units of product can be obtained from a unit of a certain factor" [29, p. 285].

R. Koch, on the contrary, says productivity is "every measure of production output divided by a measure of initial outlay (i.e. profit per unit of initial capital)". Apart from that, productivity is never an unambiguous goal in itself: by its evaluation one must consider the adopted measure and the motives which determined its choice. Often, a very good measure of productivity in many situations is the economic value added [14, p. 199].

Literature on the subject distinguishes between partial and total productivity. Partial productivity is the relation between total number of products (or number of products of certain type) and the amount of particular types of resources used for their manufacturing. Thus, this productivity refers to different production factors. Therefore, one can speak of: work productivity, capital productivity, land productivity, energy and resources productivity. Total productivity is the relation between the total number of products and total amount of resources used for their manufacturing [24. p. 341].

A Bobak, however, distinguishes between standard and structural productivity. Standard productivity (turnover) is the relation between total sales revenues and cost (value) of the production factor (resource) used. It allows comparing the revenue index in time that is the amount of revenues which falls on a monetary unit ploughed into project from the company resources. This type of productivity is distinguished by activity of production factors, as it is used in the economic processes.

Standard productivity is biased by the error of inadequacy, while only one factor determines the end effect. Standard productivity which produces effects through specific types of company activity aims at eliminating this problem. A necessary condition for its calculation is finding the part the particular types of activity have in the total company revenues, that is the end effect. Structural productivity is the relation of divided end effect (falling on a given activity) and costs of this type of activity. Statistical key figures used in this case serve the purpose of dividing the end effect into particular types of activity [4].

As stated by A. Kosieradzka [17], observation, evaluation and analysis of productivity in a company is a tool of successful management, and it enables:

- evaluation of results achieved by the company in comparison to other companies within the same industry,
- identification of 'weaknesses', that is these fields of operation which are the reason for poor productivity and which require improvement,
- establishing programs of productivity improvement;
- establishing strategic plans of a company,
- observation of trends of changes of partial and total productivity indices,
- linking company payroll policy with its productivity.

Market requirements force companies to constantly improve productivity and search for new ways of increasing it. In many countries, Japan in particular, increasing productivity is treated as a sort of company philosophy and forms a special movement towards productivity [24, p. 34].

4. Economic efficiency

Efficiency reveals itself in each purposeful human activity. However, when speaking of company results' analysis, it is necessary to: identify the effects, measure them, find a proper basis for comparison and formulate methods for synthetic evaluation of effects [2, p. 191].

Economic efficiency may be viewed as "a result of economic activity, defined by the relation between the effect and the initial outlay" [Polish Language Dictionary, PWN, Warsaw 2004]. An important feature of economic efficiency is the purposefulness of action. The scope of meaning of economic efficiency changes in time and, therefore, one can speak of a defined rela-

tion between the achieved results and initial outlay as well as relation between activity goal and the means necessary for its achievement.

Economic efficiency is an important tool of management efficiency measurement, and is viewed as a certain boarder-line for achieving best results [2, p. 191].

Economic efficiency is related to productivity. At the same time, it is important to bear in mind a famous statement by M. Imai (president of Kaizen Institute): "even the biggest fool is able to increase his work efficiency, if he spends the proper amount of resources for this purpose. The true achievement is to increase efficiency without investing in new equipment" [2, p. 191].

In his actions, a manager has to use a broad spectrum of economic indices, which make the resource management easier. Manager concentrates his attention on the parameters of capital profitability and those referring to the ability to pay bills [19, p. 139].

Usually, "partners of a company are mainly interested in its liquidity ratios. This refers to banks which grant short-term loans and to suppliers who grant commercial credits. What is important for them are the current assets to current liabilities liquidity ratio. Current liabilities cannot exceed the level of current assets" [19, p. 139].

In a broader sense, the term economic efficiency refers to "the best results in production or distribution of products and services under the lowest costs. Efficiency is measured with the use of synthetic, partial indices of resource management productivity. Those indices, however, do not express precisely the efficiency of particular production factors, or the efficiency of a company as a whole.

The effects of economic activity are very complex: indirect and direct, positive and negative, desirable and undesirable. Many types of effects may be distinguished, i.e.: increase in work efficiency, increase of foreign exchange due to export of new production, increased profits, increased production volume, increased production quality as well as deterioration of working conditions, deterioration of environment…" [24, p. 100].

On the other hand, the efficiency of a company may be measured with the use of such variables as:

- productivity, that is output-input ratio,
- morale, that is the level of satisfaction of employees' material and emotional as well as higher needs, as a result of attaching more sense and meaning to goals and tasks,
- adaptation, that is company care about client satisfaction, high quality of products and services,
- flexibility, that is the degree of company adaptability to changes,
- institutionalization, that is the degree of society support for company's mission, goals, norms and values,
- stability that is low level of disturbance, good relationships between employees, managers and clients of the company [7, p. 193].

If the problems of economic efficiency evaluation are referred to production activity of organization, then it should be assumed that this efficiency will be determined by three factors:

- initial outlay incurred for the preparation of means for activity,
- effects in the form of new means (products),
- time of realization of specific action, in which the systems are used and the effects are generated.

5. Organizational Efficiency

Organizational efficiency is the ability of a company to currently and strategically adapt to changes in the environment, as well as productively and economically use its resources in order to realize the adopted structure of goals [7, p. 100].

It can be achieved when it is treated as a process for development. The true nature of efficiency is, therefore, a process, interactional process, which encompasses phenomena taking place inside of organization, as well as between the organization and its surrounding.

In the theory of organization management, the term efficiency is often replaced with the term performance. It is believed that the organization performs better, the bigger the degree to which it realizes its goals and the smaller the time and resources outlays for their realization [24, p. 100].

Organizational Efficiency is ensured by such factors as: product, plant, processes, programs and personnel. [18, p. 153, 158]. Those factors influence competitive advantage through: product – clear functions and unique operational characteristics; personnel – skills, training; plant – specific functions, operations, technologies; programs – quickness, preciseness, delivery

punctuality, supply; processes – specific methods of work organization [2, p. 195].

Effectiveness - is the measure of the degree of goal realization. Result, that is the goal, is the anticipated state of nature, which we want to approach through our actions. We can either fully approach the goal (the result), approach it partially or not approach it at all (stand still), or even get farther from our goal. Our actions can, therefore, be:

- fully,
- partially,
- not at all (neutral),
- counter-effective (negative) [13, p. 22-24].

Natural striving of every thinking human being is to achieve maximum effectiveness of his actions. All normal people aim at achieving full and complete effectiveness of action. However, not everybody give a lot consideration to the conditions of goal realization, being under the illusion that the success will come by itself [13, p. 23].

Table 1. Company efficiency ratios (*source: [19, p. 140-141]*)

RATIOS			
I. Operating efficiency	**II. Liquidity**	**III. Profitability**	**IV. Market ratios**
Return on sales = Net Income / Sales	**Debt ratio =** Total Debts / Total Assets	**Fixed Capital Structure Ratio =** Equity / Long-Term Liablilities	**Nominal Value of Ordinary Share =** Share Capital / Number of Ordinary Shares
Profit margin = Net Income / Capital Employed	**Equity to Fixed Assets Ratio** = Ownership Equity / Fixed Assets	**Return on Capital** = Net Income + Financial Costs / Fixed Capital	**Earnings per share** = Income *minus* tax *minus* preferred stock / Number of Ordinary Shares
Payback Period = Capital Employed / Net Income	**Fixed Assets Ratio** = Fixed Assets / Total Assets	**Financial Costs Ratio** = Financial Costs / Average Long-Term Liabilities and Credits *minus* Free Cash	**Dividend per Ordinary Share** = Dividends Paid / Number of Ordinary Shares
Turnover of Capital Employed = Sales / Capital Employed	**Current Assets Self-Financing Ratio** = Current Liabilities / Current Assets	**Return on equity=** Net Income / Average Total Equity	**Dividend ratio** = Dividend per Share / Share Market Value
Fixed Capital Investment Ratio = Fixed Capital Investment / Amortization	**Current Ratio =** Current Assets / Current Liabilities		**Return on Share** = Eernings Per Share / Share Market Price
	Assets Liquidity Ratio = Current Assets / Total Assets		
	Net Assets = Current Assets *minus* Current Liabilities		

An effective organization is characterized by the following skills: it successfully wins resources, manages them appropriately, achieves the marked-out goals and fulfills the needs of its employees [2, p. 215].

Managerial effectiveness is one of the basic requirements in the game of organizational effectiveness and is the most important input in the organization development. Effectiveness is the hope for economic productivity and social living of a modern society [6, p. 186].

Second basic form of efficiency is the benefit (B). "There is a difference between a useful result and costs of actions" [11, p. 19]. Nonetheless, according to another concept, "it is the difference between utilitarian result and the outlays required for its achievement – that is, it is the utilitarian effect (E) minus outlays (C - costs)" [13, p. 22-24].

$$E - C = B \tag{1}$$

as the cost of action (outlays), we will obtain the Benefit, similarly to effectiveness, may be positive, neutral or negative. If we take R as an utilitarian result and C following situations [13, p. 24; 11, p. 24]:

R > C – beneficial action
R = C – neutral action from the point of view of benefit
R < C – unbeneficial action.

At the same time, both the effects and the outlays should not necessarily be viewed only in the financial dimension, but rather in a general one. One can 'scrape together' big amount of money, but his health or family relations may deteriorate. On the other hand action could be ineffective but turn up to be beneficial. Let us assume that somebody wanted to write his doctoral thesis. He went to the library and read books and, at the end, failed to write the thesis but met a beautiful librarian and married her eventually [13, p. 24].

There exist the following variants of relationship between effectiveness and benefit: [11, p.19-20]:

- effective but unbeneficial action,
- ineffective but beneficial action,
- effective and beneficial action – efficient action,
- ineffective and unbeneficial action.

Third basic form of efficiency is the economy. W. Kieżun defines it as "relationship between utilitarian effect (E) and costs (C) of action" and W. Kobyliński calls it the quotient of effect and outlays [11, p. 25; 13, p. 20]:

$$E_c = \frac{E}{C} \tag{2}$$

where:

E_c – economy,
E – utilitarian effect,
C – costs.

The essence of economy is described by the relationship between effects and outlays needed for their achievement. If this is the case, then:

$E_c > 1$ – action is economic;
$E_c = 1$ – action is economically neutral;
$E_c < 1$ – action is not economic.

A natural striving of every thinking human is increasing this ratio of economy, so that it is as big as possible and higher then 1. This can be achieved in two ways:

- increasing the effect under constant costs

$$\frac{E \uparrow}{C \rightarrow} \tag{3}$$

or

- the same effect under decreased costs

$$\frac{E \rightarrow}{C \uparrow} \tag{4}$$

These are two different ways of increasing the economy ratio of our actions. When speaking about increased effect under constant costs, we refer to the type of economy that can be called productivity (3). On the other hand, if we decrease costs, we refer to the second form of economy, which can be called economizing (4) [13, p. 25-26].

Organizational efficiency may also be regarded from the point of view of profit maximization with the use of different means. Such maximization, if achieved with the use of economic and technical means, is connected with productivity. If its achievement is accompanied by other non-economic or political means, the increased efficiency does not contribute to increase of productivity. Increase of efficiency achieved with both mentioned types of means usually manifests itself as: storing energy, growth, survival and endurance of organization and as increase of organization's control over external environment [10, p. 264-265].

In Polish literature, an interesting attempt to build a multi-criterion model of organizational efficiency evaluation was made by M. Bielski and J. Olszewski. Namely, they distinguished seven dimensions of efficiency and defined for each of them appropriate criteria

of efficiency and their measures or indicators [3, p. 120].

In the above mentioned theory, the following dimensions of organizational efficiency were distinguished:

- material, referring to realization of company's mission,
- economic, referring to relation between effects and outlays,
- system, describing "health" of the organization system and its ability to exist in a given surrounding,
- "political", referring to organization's relationship with its surrounding,
- political – without the inverted commas – referring to the organizational efficiency in preserving (or disturbing) the existing political and social order in a country,
- cultural – referring to the ability of an organization to preserve and/or change existing cultural values and norms in the social surrounding,
- behavioral – representing the interests of members of an organization [8, p. 87].

Material dimension refers to realization of the genotype function of the organization. It says how effective an organization is in fulfilling specific social needs and to what degree it achieves its external goals. Similarly to efficacy from the praxeology point of view, this dimension does not consider the cost of achieving goals. Therefore, this dimension has greater meaning in evaluation of efficiency of non-profit organizations, which fulfill social needs that are harder to quantify as outlays and effects. For example, a measurement of efficiency of school or university should be the level of education of its graduates and not the cost of their training. However, this dimension has also got meaning when efficiency of some economic entities is evaluated, especially in case of lack of some products or services in the market [3, p. 114].

Economic dimension (economic efficiency) encompasses criteria which in various ways present the relation between effects and outlays. If it is the relation between effects and outlays, then the criteria are: performance (people, equipment), productivity (fixed assets, property) or profitability. This corresponds with praxeological concept of economy. If there is a difference between effects and costs, it is measured by profit (reflecting praxeological benefit).

Economic efficiency is relatively easy to determine in economic entities, although even in this case exist effects and costs which are hard to present in terms of money (i.e.: intellectual, knowledge input of specialists). In non-profit organizations the economic dimension has often got smaller meaning than the material dimension; simultaneously, the economic measurability of outlays and - even more so – effects, is smaller. The measure of efficiency in these organizations is often the dynamics of outlays, i.e.: their decrease in comparison to the previous period while keeping the effects at the same level, expressed in material terms (i.e.: by the number of beds or patients in a hospital, students in a university, etc.) [3, p. 114-115].

System dimension (system efficiency) refers to "health" of the organization system and its ability to exist in a given surrounding. This dimension is especially underlined by the supporters of system approach to organizational efficiency. Without doubt, it is an important aspect of this efficiency. However, bringing the whole issue to this aspect only, brings about the sin of one-sidedness, similarly to the purposefulness approach. The evaluation criteria in case of this efficiency dimension are the long-term goals of an organization: survival and development, as well as adaptation to the changing environment.

It should be noted – says M. Bielski – that the goal of surviving cannot be graduated, as the organization either exists or not. Nonetheless, even in this dimension, the efficiency can be graduated, as a state of threat to the survival, i.e. threat of bankruptcy, may itself be an indicator of low organizational efficiency. Development and adaptation will reveal themselves in organization growth, investments, starting new businesses, expanding into new markets etc. [3, p. 115].

"Political" dimension ("political" efficiency) refers to organization's relationship with its environment. D. Katz and R. L. Kahn point out to the fact, that the ability to run a policy towards the environment by the organization is, next to efficiency, and important element of efficiency. With the same efficiency of transformation processes, organization efficiency may be different, depending on skillful placing of orders, cleverness in trade negotiations, right choice of place for investment etc. "In general, […] it can be said that transactions with the environment have, to some extent, a political character…" [10, p. 252].

The result of "politics" in this sense is the exploitation of the environment, which is, obviously, only possible within limits in which it does not threaten the future of the organization (limits to "robber economy"). "Political" actions may just as well be directed towards inside

of the organization and aim at achieving the best possible (from the point of view of organization) conditions of people's participation, i.e.: work in extra hours, intensification of efforts, limitation of wage claims. Criteria of the "political" dimension can be bargain force of the organization against the environment, monopolistic position, bargain force in negotiations with employees and other stakeholders of the organization.

The inverted commas in this dimension refer to the organization politics towards other entities, sort of "small politics", as opposed to "big politics" [3, p. 115-118].

Political dimension (political efficiency) – without inverted commas – refers to company efficiency in preserving (or disturbing) the existing political and social order in a country. It is organizational efficiency from the point of view of not the organization itself, but the ruling class or political party. Although organization efficiency is only seldom officially evaluated with the use of this dimension, it is used commonly in real life. In countries ruled by communists, especially soon after overtaking the power, this dimension ousted out all the others, especially the economic one. Also, it influenced investment decisions which aimed at creating big economic entities and, at the same time, working class centers [3, p. 118].

Cultural dimension (cultural efficiency) refers to the ability of the organization to preserve values and norms, which enable the society to keep its cultural identity, as well as to contribute to the development of culture (in broader understanding: technical, organizational, sanitary, and not the strict sense) and to adapt to the changes in culture on global scale [3, p. 118].

Behavioral dimension (behavioral efficiency) encompasses such criteria as job satisfaction, increase of internal conflicts, employees' morale, etc. This dimension reflects the interests of members of an organization, and is used for evaluation from their point of view, but not only. Efficiency of an organization in this dimension may increase the efficiency in other dimensions, such as: material, economic, system. It might also be positively correlated with the political dimension – conflicts in workplaces, when they exceed certain degree of intensity, often turn into political conflicts (i.e.: conflicts in the Gdansk Shipyard in 1970 and 1980, strike of miners in Great Britain). On the other hand, this dimension could be totally inconsistent with the others, especially with the "political" and economic ones (high efficiency and high satisfaction do not always accompany each other) [3, p. 119].

In the Polish literature concerning organizational efficiency, purposefulness is also represented by L. Krzyżanowski [15]. What is doubtful, however, is the measurability of goals in an objective way. Goals are sometimes hard to grasp. According to D. Katz and R. L. Kahn, one of the key factors serving the purpose of organizational efficiency evaluation are the relations with the environment (transactions, bargain force, etc.). This argument is also not settled by the proposal of S. Kownacki. Therefore, at this point, it is interesting to present, above all, the scheme of efficiency dimensions of M. Bielski [3, p. 62]:

- end goals – means and their use (most similar to purposefulness approach),
- entry efficiency – transformation efficiency – exit efficiency (most similar to system approach),
- economic measurement of efficiency – behavioral measurement of efficiency (presenting the content of social sub-system of an organization),
- goal realization – maintaining the organizational integrity – adaptation,
- production – efficiency – morale – adaptation – development.

These proposals point to the complexity of the issue of organizational efficiency evaluation. On this background, it is clearly visible that praxeological evaluation criteria of aspects of organizational efficiency evaluation, useful as they are, do not completely exhaust the matter of synthetic efficiency evaluation. Other concepts of multi-criteria efficiency evaluation aim at measuring efficiency on the basis of goals, conditions to be met and standards. Subsequently, their authors define goals as "desired end result determined by management", and the conditions to be met are dependent on the type of organization. I.e. In a company this could be the quality of products, in school – quality of education, in hospital – number of successful surgeries, etc. Nonetheless, also this proposal appears to be incomplete [1, p. 106].

6. Managerial efficiency

While the problem of efficiency (especially economic) has been sufficiently elaborated upon theoretically in the literature, there is no such basis in the universal sense. Problem of efficiency as researched by the theory of organization and management is way more complex than in case of pure economy. It results from the fact that organization theory researches the efficien-

cy of divergent goals, not only economic, but also those that can be attributed to economic entities and their constituent parts. Therefore, these can be even humanistic goals of functioning of organizations, such as: security, distinction, coherence, survival. In the theory of organization, concepts of adequate goals hierarchy and hierarchical organizational structure are used and the degree of inconsistence of goals realized by the organization and its specific parts is researched [1, p. 88-89].

Managerial efficiency measurement may be viewed from different angles: technical and economic, praxeological, administrative, bureaucrat, adaptive, humanistic, personality, organizational, ecological and ethical [7, p. 151].

Technical and economic aspect of efficiency. Identifying the concept of efficiency with the notion of productivity is typical for technicians and economists. H. Emerson, representative of the direction of scientific management, specialist from the field of organization and production management and author of the first concept of goal management, formulated twelve principles of efficiency (productivity), which deserve to draw the attention of modern managers and should be implemented in companies.

Creativity in an effective organization must be viewed as process and constant element of activity. Principles of efficiency presented by Emerson currently find full confirmation and are applied practically by those companies which base their activity on quality [2, p.193].

H. Emerson presents the 12 principles of efficiency as follows:

- clear goal and defined ideal (clearly defined goal),
- common sense,
- professional advice,
- discipline,
- fair, just behavior,
- flawless, immediate reporting,
- order in the course of action,
- standards and norms (standard ways of operation – standard methods and operations),
- adjusted conditions
- standardized working methods,
- written instructions for standardized work (written regulations and instructions),
- prize for productivity (rewarding efficiency) [7, p. 151-152].

Praxeological aspect of efficiency. "Efficiency is a feature of actions which bring some positively evaluated result, no matter if this result was intentional (efficacious action) or unintentional (efficient action). Efficiency, similarly to efficacy, may be upgradable or gradable. In the first case the action is either efficient or inefficient. In the second, the quantity and quality are considered and so the more efficient action is the one to bring bigger number of positive results or simply more valuable results: [7, p. 154-156].

Administrative aspect of efficiency. Principles of rational administration of an industrial organization were formulated and published on the basis long-term research by H. Fayol. It consisted, above all, in increasing the efficiency of managers who ran the company. In 1916 principles of efficient company management and human resources management were published.

H. Fayol made it clear, that his principles did not have an absolute nor rigid character and that they should be adjusted to each and every situation (intelligently and within reason), in order to increase the efficiency of an industrial organization's management.

Below are the 14 principles of efficient administration according to H. Fayol:

- division of work,
- authority,
- discipline;
- unity of command,
- unity of Direction,
- subordination of individual interest,
- just remuneration,
- centralization,
- scalar chain (Line of Authority),
- order,
- treating employees well,
- stability of Tenure of Personnel,
- initiative,
- team spirit (Esprit de Corps).

Bureaucratic aspect of efficiency. Concept of bureaucracy was introduced by M. Weber as a name for an organization which was supposed to reflect the highest human rationality and efficiency.

Rationality meant adaptation of an institution to all goal-oriented actions with exclusion of everything that could directly or indirectly conflict with the marked out goals.

The model of a rational, bureaucratic organization should have some specific, advisable attributes such as [7, p. 158-160]:

- purposefulness of action,
- precision of action,
- quickness,
- unambiguous character,
- activity continuity,
- discretion,
- subordination,
- minimization of conflicts,
- personal and material costs economy.

Basic principles of an efficient bureaucracy activity of M. Weber are:

- rules and procedures determine the scope of activity of organization and officials' competences,
- hierarchical structure and norms regulate the superiority-subordination relationships,
- qualifications and commitment are included in the employee work documentation,
- official is loyal to the office and not to his superior.
- official relationship is impersonal and functional with regard to tasks,
- rights and responsibilities of an official define his position in the office and in the society,
- status of an official is high due to his qualifications and permanent connection to the office [16].

Adaptive aspect of efficiency. A more modern type of efficient management of an organization which aims at improvement was proposed by R. Beckhard.

Forms of management of an organization which is open to changes look as follows:

- whole organization, its parts and units are goal-oriented and plan the achievement of goals,
- forms are results of functions; given problem, task or project imposes the way of staff organization,
- decisions are made by people who are closest to the source of information, no matter their position in the official hierarchy,
- managers are equally rewarded or punished (so called stimuli) for: carrying out short-term tasks, training their subordinates and creating efficient teams,
- people are open, speak of facts and feelings known to them (communicate). Vertical and horizontal information flows are encouraged,
- "win or lose" behavior occurs rarely; conflicts are considered problems to be solved,
- if any difficulties occur, they are rather related to realization of tasks and projects than to interpersonal misunderstandings,
- organization and its individual parts realize themselves through interactions with the environment,
- given system of values is accepted by all the members,
- work of the whole organization and its individual parts resembles research, which consists in starting feedback mechanisms in a way that enables learning from one's own experience.

Humanistic aspect of efficiency. Model of an efficient organization was first presented from the humanistic point of view, among others, by D. J. Lawless, who made the assumption that there cannot be an efficient organization without efficient teams of people. Therefore, a model of efficient team is built.

Conditions for functioning of the efficient team of D. J. Lawless are as follows:

- atmosphere which supports informal behavior and provides feeling of relaxation,
- before approaching to the realization of tasks, discussion and agreement concerning means and methods are required,
- goals and tasks must be formulated in such a way that everybody can understand them and engage in their realization,
- the rule of listening to what other people have to say should be complied with. Each and every idea should be considered seriously and nobody should be afraid of being laughed at,
- causes of disagreement should be analyzed with the thought of finding a solution in mind, and not the thought of crashing the opposing party or removing the quarreling persons,
- most decisions should be taken under certain forms of understanding and agreement. Formal vote with use of the rule of simple majority of votes is not the best basis for an efficient team cooperation,
- criticism should be common, sincere criticism should not cause threats,
- during discussion of problems, which have to be resolved, showing emotion is allowed,
- each person's assignments should be understandable and accepted by this person,
- in order for the team to be able to realize the task, the issue should be "how to perform the task in the best way?" and not the fact who has the power or who has the control,

- efficient team should always be aware of its behavior and undertaken actions [7, p. 161-162].

D. J. Lawless enumerates and describes dependent variables which are positively correlated with organizational efficiency. These variables are:

- productivity,
- morale,
- adaptation,
- flexibility,
- institutionalization,
- stability [7, p. 162-163].

Personality aspect of efficiency. Main assumption of the concept of efficient personality is that efficacy does not equal efficiency, because efficacy describes only the current level of task realization by given person, while efficiency describes the degree, to which given person exceeds his actual tasks. In the second case, therefore, "efficiency is the developmental efficacy" [7, p. 164; 22].

This difference in meanings is explained with the fact that the social environment values "efficacious behavior" more than "efficient behavior". It happens so because the first behavior is easy to evaluate and reward, while the second one is hard to evaluate in the short run, risky, uneconomic and threatens the realization of plans "for today". The drawback of "efficacious behavior" is, however, that it might be disturbed facing change, which, in consequence, leads to decrease of its efficacy [7, p. 164].

According to this author, only realization of a complete set of hierarchically organized tasks ensures strong and flexible developmental effectiveness, which is characteristic for an efficient person [7, p. 116].

Organizational aspect of efficiency. Managerial efficiency in teamwork organization may be achieved, among others, thanks to the use of six rules of B. K. Scanlan, which in practice are uncomplicated and inexpensive.

Principles of efficient teamwork organization of B. K. Scanlan are:

- define and maintain high requirements with regard to the results,
- inform people about their current position,
- introduce clear rules of communication,
- create atmosphere of encouragement and support,
- learn to delegate responsibility, rights and obligations,
- create a system for evaluating and directing [77, p. 167-171].

Ecological aspect of efficiency. The XX century was massively influenced by three inter-related factors: demographic explosion, industrialization and urbanization. Treated apart of each other as well as altogether, these factors cause threat of irrevocable changes in the natural environment of human being. These threats are magnified by extraordinary wastefulness with regard to use of resources, energy, produced goods, food, etc.

Proof of an increased ethical and ecological awareness may be the Code of Ethics in Business Activity published by the Polish Chamber of Commerce [7, p. 172-177].

There is an opinion that "in order to stay alive and develop the civilization, human being inevitably has to interfere with other beings' lives and dwellings. To be rational and ethical rather than destructive, this integration has to follow such principles as:

- principle of self-defense,
- principle of proportionality,
- principle of lesser evil,
- principle of just division.

Compliance with the above mentioned principles instead of life and death struggle introduces the well known, rational and moral rule: "live and let others live" to human coexistence with the nature [25, p. 96-99; 33, p. 61-61].

7. Problems of efficiency and effectiveness

7.1 Increasing organizational efficiency

If we assumed that activity of companies as well as their sub-systems, viewed as economic systems, should be effective, efficient and rational, then the managerial decisions should be preceded by economic calculation, which ought to constitute the basis for economic choices [2, p. 95].

Effectiveness answers the question if, as a result of activity, the set up goals were achieved. Efficiency, on the other hand, informs us about the costs that were incurred in order to achieve those goals and if these costs were exceeded by the obtained effects. Every company can be effective and efficient, effective and inefficient, efficient and ineffective and finally ineffective and inefficient. The last situation qualifies the company for

bankruptcy and liquidation. A simplified example is presented in Table 2.

Table 2. Effectiveness and efficiency of company activity *(source: [2, p. 96])*

		Degree of use of production resources	
		strong	weak
Degree of goal realization	high	high effectiveness high efficiency	high effectiveness weak efficiency
	low	low effectiveness high efficiency	low effectiveness weak efficiency

Indices of productivity and intensity. Indices of productivity of production factors are part of the efficiency ratios family. Productivity indices refer to production assets (assets productivity ratio), materials (material productivity ratios) and employees (labour productivity indices). The opposite of productivity is intensity of those factors with regard to the financial or material result, which is the assumed basis for calculations. Therefore - as pointed out by L. Białoń – such ratios as: capital intensity, material consumption, water absorption, energy consumption or knowledge intensity are used.

While the productivity ratios should increase in time, the smaller the intensity ratios, the better (maybe excluding knowledge intensity). Productivity indices describe the efficiency of production factors and intensivity indices describe the input-side of manufacturing processes [2, p. 96].

In order to diagnose the situation and improve organization results, the three efficiency levels approach is used. It may be used by the managerial cells to diagnose the situation before introducing specific solutions. Use of this approach should, at best, enable a given specialist to adjust the “remedy” to the situation. In the worst case scenario, it may occur that the proposal presented by a given department does not resolve the most urgent problems of the organization and, therefore, needs to be revised [27, p. 138-139].

7.2 Organizational level

At this level emphasis is placed on relations between the basic structural part of organization and the market, on which it operates. Factors which influence the organizational efficiency at this level are: strategy, general goals of the organization and methods of their measurement, organizational structure, method of use of resources [27, p. 138-139].

In order to conduct an efficient analysis of the social aspect of organization functioning, analysis of strategic plans of the organization is carried out – marked out goals, ways of designing and managing at the level of organization.

Organizational goals. Goals at the level of the organization as a whole result from the adopted action strategy. All the other efficiency levels and variables affecting efficiency result from organizational goals [27, p. 47].

Organization design. This efficiency variable is, above all, related to organizational structure. System approach suggests that structure analysis should contain not only the demarcation between individual organizational departments and reporting paths, but also how the work is carried out and if the present method of its realization has sense [27, p. 48].

Managing the organization. Organization might have properly formulated goals and appropriate organizational structure, which enable it to function efficiently. However, in order to operate efficiently and productively, it must be managed. The most important areas of management at the organizational level are:

- organizational goal management,
- efficiency management,
- resources management,
- point of contact management [27, p. 48-49].

The first step in efficiency management at the organizational level is to look at the current situation from the following points of perspective:

- client perspective,
- supplier perspective,
- employee perspective,
- shareholder perspective.

First task of increasing the organizational efficiency is preparation of organizational mission. After preparing the strategy, activities connected with improving the organization have to be planned (as well as management methods). This consists in elaboration of super-system organizational map and determining, on its basis, the key issues for the organization.

These are potential chances for building strategic advantage of our company or reducing the advantage of competition. During realization of this stage it is also necessary to identify the processes, which, after the improvement, will have the biggest influence on the key issues for the organization.

Process level. This level refers to all the effects of organizational functioning, which result from the network of inter-department processes, such as i.e.: designing new products, supply process, production process, sales process, distribution, invoicing and debt collection [27, p. 43].

Most basic results of the organization result from such inter-functional processes as: realization of order, invoicing, supplying, designing new products, client service or preparing sales forecasts. Three needs of efficiency at the process level are: goals, design and management.

Process goals. Because work is a result of processes, for each process we should establish goals. Process goals, which are connected with the external client (i.e. sales, providing services, invoicing) should result from organizational goals and consumers' expectations and requirements. Goals for inner-organizational processes (such as: planning, budgeting, personnel recruitment) should be formulated on the basis of inner-clients' needs [27, p. 50].

Process design. Having formulated process goals, we should make sure if the way the processes were designed enables efficient realization of our goals. This process should be logical and have the simplest possible course which enables the achievement of goals [20, p. 51]

Process management. A process, even if it has the most logical structure, will be inefficient, if it will not be managed properly. Process management encompasses the same components as managing the organization [27, p. 51-52].

Having identified the key organizational issues and process, we can initiate the project of process improvement. Next, we should realize in turn the stages of the earlier mentioned procedure. During the first stage we should define: goals, roles and operational framework of the project. Second stage is devoted to description and analysis of the current state of the process and, afterwards, designing new process in accordance with goals defined earlier. Finally, the measurement system is established.

The above mentioned tasks are realized by the management and employees who are indirectly involved in the process realization. Detailed action and implementation plan of the improved process, which encompasses all three levels of efficiency evaluation, appears during realization of the third stage [27, p. 261].

Nine variables which influence organizational efficiency. Three efficiency levels are the first dimension of the G. A. Runner and A. P. Brache's concept. The second one consists of three factors, so called efficiency needs, which influence the results on every level and, therefore, also the organizational results. Efficiency needs result from:

- **organizational**, process and workstation goals – they must be defined with the use of standards reflecting clients' expectations concerning: quality, quantity, time of delivery, time of realization and cost of product or service,
- **design method** – organizational structure, process design and workstations require some vital elements configured in the way, which enables efficient goal realization,

management method – each of the three levels of efficiency requires an appropriate method of management, which enables goal realization [27, p. 46].

G.A. Rummler, A.P. Brache state that all the time we tend to try to search for new methods of using the tools of three efficiency levels for three potential groups of users: highest level managers, managers and consultants. These might be used as:

- tools for diagnosing and improving those organizations which function inefficiently,
- method of constant improvement of systems which run efficiently,
- approach which enables formulation of new organizational strategy,
- procedure allowing us to design new organization from the beginning.

Table 3. Nine variables influencing organizational efficiency *(source: [27, p. 46])*

EFFICIENCY LEVELS	EFFICIENCY NEEDS			
		goals	design method	management method
	organizational level	organizational goals	organization design	organization management
	process level	process goals	process design	process management
	workstation level	workstation goals	workstation design	workstation management

As a result of the research carried out so far, it can be said that the described issues do not only serve the purpose of resolving specific, current problems. Implementation of the mentioned activities may influence a change in the organizational culture. Within the framework of influencing the organizational culture, it is possible to affect:

- recognition of clients' needs as a point of reference for all organizational activities,
- introduction of responsibility for taken actions on the basis of results of efficiency evaluation system,
- minimization of conflicts between departments,
- introduction of a participation management style, that is, such management style, in which the voice of all the people interested in resolving particular problems is taken into account,
- creation of such working conditions which are favorable to efficiency and job satisfaction improvement [27, p. 263-264].

8. Summary

Company which wants to maintain its position in the market must: be productive, use the material and human resources efficiently and positively influence the relation between effects and outlays [2, p. 197].

When approaching to evaluate company efficiency, the following conditions must be taken into account: company and its individual parts are goal-oriented; forms are results of functions, particular problem influences the way people should be organized; system of stimuli functions in such a way that managers of different levels are rewarded and punished to the same extent; employee training and creation of task-oriented teams take place; there is an effective vertical and horizontal communication; conflicts between people are treated as problems to be solved; organization is an open system, which has relationships with the environment; there is a system of values supported by the managers; functioning of the whole organization serves the purpose of starting processes which enable learning [7, p. 37-64].

The process of achieving efficiency must engage all the factors, which may influence the success of the organization. It is, therefore, necessary to determine the basic and supporting goals as well as strategies of their realization, to care for the quality of inner activities within the organization and, for the same purpose, full readiness for cooperation and flexibility towards changes. Company, which is not able to subject itself to the process of changes, is doomed to leave the market. Therefore, there must not be a single day, when there is no change for the better in the organization [2, p. 192].

Management efficiency depends on the used rules and aspects of good management. It is a common belief, that quality management (TQM) influences the economic efficiency, which further impacts the organizational efficiency. Total quality management leads to improvement of organization, personnel, information flow and communication between employees [2, p. 96].

An important tool for improvement of efficiency is the effective leadership. It starts in the moment when vision is formulated and expands over the strategy, which is supposed to lead to market success. Efficient leadership combined with TQM provides the result of appropriate goods achieved from the first time [21, p. 12-72].

Other important tools for improvement of efficiency are: reengineering, motivation systems and kaizen, which is the philosophy of introducing small, simple changes with the use of small steps approach. Simultaneously, it is important to underline that the initiative, which leads to changes, comes from the place where the product is being manufactured and the value is being added. Kaizen is a process which consists in adopting the mentality of constant improvement [2, p. 192].

Efficiency is a measure of results. It consists in asking a simple question: Was the task accomplished? Rewarding people within the organization requires, therefore, the existence of an agreed upon criterion of evaluation of their efficiency.

The fact, whether such criterion successfully describes the efficiency has no meaning; if we grant a prize on the basis of effective execution of tasks, we treat efficiency as its measure. In many works efficiency is treated as the only criterion. However, together with tasks becoming less normalized and routine, it becomes more difficult to measure efficiency. Consequently, defining efficiency becomes more and more complex matter [26, p. 394].

Nonetheless the managers in corporations as well as those who directly monitor separate economic entities rely more and more on linking the rewards (especially remuneration) with efficiency. Such different companies as i.e.: American Broadcasting, Security Pacific National Bank, Sears, Roebuck and Dow Chemical all measure the economic efficiency of their economic entities, compare results with those of their competition and grant rewards accordingly [26, p. 394].

The basic condition of efficient management becomes the understanding and respect for human being in an organization and the awareness that "no organization can exist, if its members will not accept the tasks which are expected from them and will not be motivated to execute them" [10, p. 199-130].

It is similar in case of companies, which will achieve success in the future. It will be those of them which receive the most from their people (with regard to creative use of equipment – the same in all the companies). Therefore, from the point of view of increase in efficiency, very important role is played by: enriching work, which is a motivation strategy that underlines motivating function of the employee's own work.

Employees are responsible for successful realization of tasks. Usually, at this point the features, which influence individual motivation and activity, are pointed out:

- variety of skills,
- setting the goal,
- meaning of the task,
- autonomy,
- return effect in the form of quantity of direct and clear information, which is received by the employee [20, p. 458, 463].

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