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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 Adamiński (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

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DECLARATIVE MODELING FOR PRODUCTION ORDER PORTFOLIO SCHEDULING

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Abstract: A declarative framework enabling to determine conditions as well as to develop decision-making software supporting small- and medium-sized enterprises aimed at unique, multi-project-like and mass customized oriented production is discussed. A set of unique production orders grouped into portfolio orders is considered. Operations executed along different production orders share available resources following a mutual exclusion protocol. A unique product or production batch is completed while following a given activity's network order. The problem concerns scheduling a newly inserted project portfolio subject to constraints imposed by a multi-project environment. The answers sought are: Can a given project portfolio specified by its cost and completion time be completed within the assumed time period in a manufacturing system in hand? Which manufacturing system capability guarantees the completion of a given project portfolio ordered under assumed cost and time constraints? The considered problems regard finding a computationally effective approach aimed at simultaneous routing and allocation as well as batching and scheduling of a newly ordered project portfolio subject to constraints imposed by a multi-project environment. The main objective is to provide a declarative model enabling to state a constraint satisfaction problem aimed at multi-project-like and mass customized oriented production scheduling. Multiple illustrative examples are discussed.

Keywords: project portfolio, scheduling, routing, declarative modeling, customized production.

1 Introduction

The current manufacturing environment can be characterized in terms of many factors but the key one for companies confronting the challenge of remaining competitive in an era of globalization is undoubtedly the capability of fast and accurate decision making, especially so in the domain of mass customized production/services management. Most companies, particularly small- and medium-sized enterprises (SMEs), have to manage various projects sharing a pool of constrained resources and taking into account various objectives at the same time. That means SMEs have to deal with multi-project-like and mass customized oriented production. In that context, executives want to know how much a particular production order will cost, what resources are needed, which resource allocation can guarantee due time production order completion, and so on. Consequently, the decision support tools employing methods and techniques aimed at such marked demands caused by consumer need are of great importance. Such methods enhancing an online project management, and supporting a manager in the course of decision making, for example, in the course of evaluation whether a new order can be accepted to be pro-

cessed in a multi-project environment of a manufacturing system at hand or not, could be implemented into dedicated decision support system (DSS) [7] tools or into on-demand decision support software packages, for example, cloud computing available such as Software as a Service (SaaS).

The main objective of a DSS aimed at multi-product production flow planning is the coordination of processes and activities related to work order processing, that is, the transportation, inventory management, warehousing, and manufacturing. In other words, the goal is to achieve a well-synchronized behavior of dynamically interacting components, where the right quantity of the right material is provided in the right place at the right time.

Declarative approaches [2, 7, 13, 20, 23 and 25] to systems and/or process modeling promise a high degree of flexibility. Constraint programming (CP) is an emergent software technology for declarative description and effective for solving large combinatorial problems especially so in areas of integrated production planning. In that context, CP can be considered as a well-suited framework for the development of decision-making software supporting SMEs in the course of a multi-

project-like and mass customized [17, 20, 23] oriented production where unique production orders grouped into portfolios have to be completed in assumed time periods.

Therefore, the considered problem regards the development of a CP-driven modeling framework providing a methodology for DSS design aimed at prompt and interactive service to a set of routine queries formulated either in a direct or reverse way: Whether a given production order portfolio (POP) [4, 5, 24] specified by its cost and completion time can be completed within the assumed time period in a manufacturing system in hand? Which manufacturing system capability guarantees the completion of a given POP ordered under assumed cost and time constraints? The sought reference model, encompassing consumer order requirements and available production capabilities, has to provide a formal framework allowing one to develop a class of DSSs dedicated to interactive production flow planning subject to multi-project environment constraints.

The rest of the paper is organized as follows. Section 2 introduces a concept of project portfolio management through a declarative modeling framework and project portfolio scheduling. Section 3 provides a reference model for the project portfolio scheduling problem. Two approaches to its solution, called straight and reverse, are discussed in deep modeling problem formulation focused at POP prototyping. The methodology behind DSS dedicated to project portfolio scheduling and conclusions are presented in Sections 4 and 5, respectively.

2 Project Portfolio Management

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 the maximization of profit [7, 9, 19, 21]. In that context, executives want to know how much a particular production order will cost, what resources are needed, which resource allocation can guarantee due time production order completion, and so on. In other words, they are searching for responses to the standard, routine questions, such as [7, 8, 13, 20, 24]: Can the production order be completed before an arbitrary given deadline? What is the production completion time following as-

sumed robot operation time? Is it possible to undertake a new production order under given (constrained in time) resource availability while guaranteeing disturbance-free execution of the already executed orders? What values and of what variables guarantee the production order will be completed following an assumed set of performance indexes?

2.1 Modeling Framework

The problems behind the quoted questions belong to the class of so-called project scheduling. 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 set of performance measures. The scheduling of multi-stage batch processes has received significant attention from researchers in the process systems engineering community. Existing methods assume that routing and allocation as well as batching and scheduling decisions are made independently, that is, each production order is treated as an activity network and is assigned to processing units, and then divided into a number of batches (batching), and sequenced (scheduling). Several techniques have been proposed in the past 50 years, including MILP [18, 20, 22], branch-and-bound [11], or more recently artificial intelligence. The last class of techniques concentrates mostly on fuzzy set theory and CP frameworks [1, 5, 14].

Very limited works, however, focus on the joint technological processes, transportation routing, and financial aspects [6]. Constraint programming/constraint logic programming (CP/CLP) languages [6, 11, 15, 20] seem to be well suited for modeling such real-life and day-to-day decision-making processes [10].

Furthermore, there is another aspect of the addressed problem, namely multi-criteria decision making under uncertain conditions. Fuzzy multi-criteria decision making is primarily adopted for selecting, evaluating, and ranking alternative solutions to problems [7]. To do this in a way compatible with real-life settings necessitates the use of stochastic and fuzzy logic frameworks [18]. The fuzzy model of project portfolio online control can be specified as a declarative one and then implemented using CP techniques and finally implemented as a decision support system [7]. Some applications of fuzzy set theory in production management [26] show that most of the research on project

scheduling has been focused on fuzzy PERT and fuzzy CPM.

Of course, in the general case a hybrid model specified by discrete distinct and/or imprecise (e.g., fuzzy) variables and renewable and/or non-renewable resources can be considered [1, 5, 12 and 14].

The assumed reference model enabling a descriptive way of a direct or reverse problem formulation encompasses a constraint satisfaction problem (CSP) structure while taking into account different types of variables and constraints of project planning problems.

Therefore, an approach proposed assumes a kind of reference model encompassing an open structure enabling one to take into account different types of variables and constraints as well as to formulate straight and reverse kinds of project planning problems. In this context, the contribution provides the framework allowing one to take into account both crisp and fuzzy data describing modeled objects and then to treat them in terms of the CSP [11].

In order to illustrate the approach proposed, let us focus on a reference model of decision problem encompassing equilibrium between possible expectations regarding potential order completion (e.g. following a set of routine queries) and available production capabilities. The considered decision problem concerns of resources conflict resolution, that is, conflicts arising when different activities simultaneously request their access to renewable and non-renewable resources of limited quantity.

2.2 Constraint Satisfaction Problem

Constraint satisfaction problem (CSP) is determined by the set of decision variables $X = \{x_1, x_2, \dots, x_n\}$, the family of variable domains $D = \{D_i \mid D_i = (d_{i,1}, d_{i,2}, \dots, d_{i,j}, \dots, d_{i,m}), i = 1, \dots, n\}$, and the set of constraints $C = \{c_i \mid i = 1, 2, \dots, l_c\}$ encompassing relations linking variables. Each constraint c_i can be seen as the relation defined on the relevant subset of variables $X_i \subset X = \{x_1, x_2, \dots, x_n\}$. Consequently the CSP is denoted as follows: $CS = ((X, D), C)$.

Consider the vector $V = (v_1, v_2, \dots, v_n) \in D_1 \times D_2 \times \dots \times D_n$. The vector V such that all the constraints hold is treated as the admissible solution of CS . Let us suppose, the constraint c_i defined on the subset $X_i = \{x_1, x_k, \dots, x_m\}$ follows the logic value equal

to “true” (noted as $w(c_i) = 1$); in this case there exists $V_i \in D_1 \times D_k \times \dots \times D_m$ such that c_i holds. In that context, the set of admissible solutions is defined as follows:

$$V = \{V = (v_1, v_2, \dots, v_n) \mid v_i \in D_i, i = 1, \dots, n, w(c_1) = w(c_2) = \dots = w(c_{l_c}) = 1\}.$$

Therefore, CSP can be seen also as a triple set (data, constraints, query), that is, the set of variables and family of variable domains, the set of constraints, and the question: Does there exist non-empty set V ? Of course, in the general case, instead of an admissible solution an optimal one can be searched for, as well.

Solution strategies are based on two subsequently used mechanisms, that is, constraint propagation and variable distribution. Variable distribution can be executed either through systematic (e.g., breath-first-search) or stochastic search of the whole or constrained state space of potential solutions obtained from constraint propagation. The searching strategies are implemented in constraint logic programming or CP languages such as CHIP, OzMozart, ILOG, and so on [11, 13, 18 and 25].

2.3 Project Portfolio Scheduling

The declarative model considered assumes that each new portfolio of production orders can be accepted for execution in a given workshop only if its performance will do not disturb other job executions while its completion will follow presumed demands imposed by customers, for example, deadlines, production costs, and so on. The above problem belongs to multiple projects or POP scheduling and can be modeled and then resolved by different methods mentioned above. However, the advantages of using CP technique are: (1) it reduces the search space and therefore, it can find a feasible solution in a short time, which is required for online control; (2) it can be implemented in standard software such as ILOG and PROLOG [18, 25].

In case an unforeseen event occurs, for example, caused by the occurrence of production flow disturbance and/or new production orders, the current schedule of production flow becomes infeasible. Thus, it is necessary to reschedule project portfolios and to reallocate resources in online mode. The idea of proactive scheduling is presented in Fig. 1.

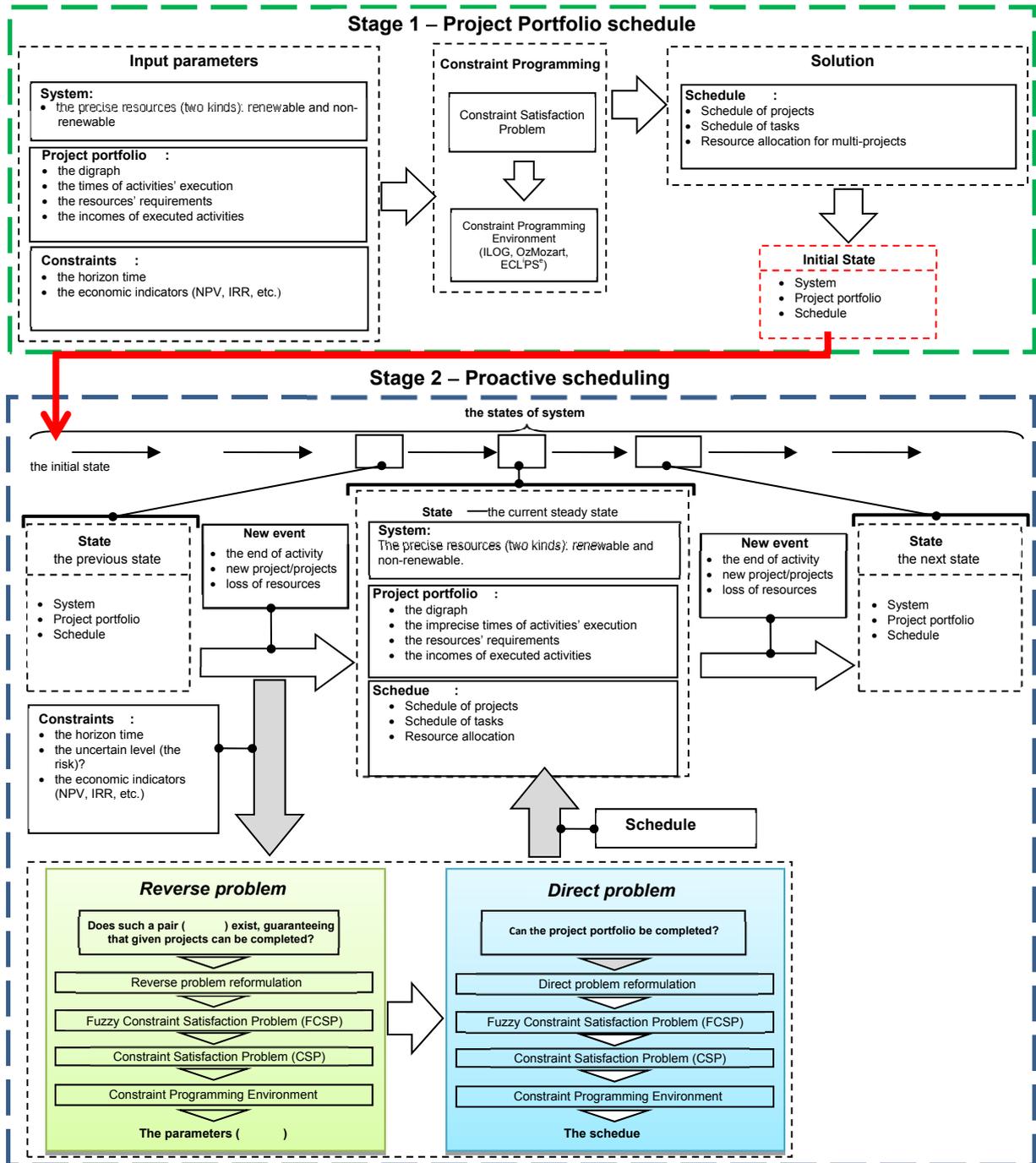


Figure 1. The idea of multi-product production flow scheduling and rescheduling

To be able to achieve this requires solving the problem in two steps: first, as a reverse problem and then as a direct problem. The reverse problem is formulated to establish the range of values of parameters guaranteeing a feasible plan exists. Therefore, the result from the reverse problem will guarantee finding a feasible solution in the direct problem and significantly reduce computational time. The solution of the reverse problem will be used as an input parameter for the direct problem, which aims to find a new plan for projects

with minimum cost. In other words, besides direct formulation of the scheduling problem its alternative statement formulated as a reverse scheduling problem can be as follows: Which values of the system parameters guarantee that the set of orders will be completed while giving a certain set of values for performance indexes? In the case of any new event, caused for instance by including a new project, a new system state has to be considered to determine a new project portfolio schedule. In that context, the proposed approach

involves solving both direct and reverse problems for systems where project portfolios (specified by fuzzy data [1, 12]) change over time as a result of randomly occurring events.

Due to the high complexity of planning problems, it is assumed that reverse/direct problems are represented in constraint satisfaction formalism to give the current state of the system. Therefore, the proposed approach assumes the portfolio rescheduling takes place at states; the declarative model representing a reverse/direct problem of production flow scheduling is transformed to CSP and then solved using CP-based techniques. Its distinct advantage is that it separates the problem statement and its resolution methods. In addition, integrating the cash flows and the resource allocations with data describing the stochastic nature of possible disturbances is considered in the online control.

The proposed methodology should provide the following contributions:

- a method for follow-up planning and online control subject to financial, time and resource capacity constraints, in an uncertain multi-project environment;
- an approach solving the reverse problem for project portfolio planning by integrating stochastic, fuzzy logic and the CP methods.

3 Declarative Modeling

Let us consider the reference model of a decision problem concerning multi-resource task allocation in a multi-product job shop assuming the precise character of decision variables. The model specifies both the job-shop capability and production order requirement in a unified way, that is, through the description of determining the 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 if such conditions hold, the response to associated questions is positive.

3.1 Reference Model

The reference model considered specifies both SMEs and project portfolio in terms of describing their variables and constraints.

Set of decision variables – X:

• SME – a job-shop perspective

Given an amount lz of renewable discrete resources ro_i specified by (e.g., workforce, machine tools, automated guided vehicles, etc.): $Ro = (ro_1, ro_2, \dots, ro_z)$.

Given amounts $zo_{i,k}$ of available renewable resources $zo_i = (zo_{i,1}, zo_{i,2}, \dots, zo_{i,h})$, where $zo_{i,k}$ limited amount of the i -th renewable resource available at the k -th moment of H : $H = \{0, 1, \dots, h_{\max}\}$, specified by $Zo = (zo_1, zo_2, \dots, zo_{lz})$.

Given amount ln of non-renewable resources (i.e., money) rn_i specified by: $Rn = (rn_1, rn_2, \dots, rn_{ln})$.

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

• Project portfolio

Given a set of projects $P = \{P_1, P_2, \dots, P_{lp}\}$, where P_i is specified by the set composed of lo_i activities, that is, $P_i = \{O_{i,1}, \dots, O_{i,lo_i}\}$, where:

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

$s_{i,j}$ – the starting time of the activity $O_{i,j}$, that is, the time counted from the beginning of the time horizon H ,

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

$Tp_{i,j} = (tp_{i,j,1}, tp_{i,j,2}, \dots, tp_{i,j,lz})$ – the sequence of moments the activity $O_{i,j}$ requires new amounts of renewable resources: $tp_{i,j,k}$ – the time counted since the moment $s_{i,j}$ 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: $0 \leq tp_{i,j,k} < t_{i,j}$; $k = 1, 2, \dots, lz$.

$Tz_{i,j} = (tz_{i,j,1}, tz_{i,j,2}, \dots, tz_{i,j,lz})$ – the sequence of moments the activity $O_{i,j}$ releases the subsequent resources: $tz_{i,j,k}$ – the time counted since the moment $s_{i,j}$ 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: $0 < tz_{i,j,k} \leq t_{i,j}$ and $tp_{i,j,k} < tz_{i,j,k}$; $k = 1, 2, \dots, lz$.

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

$Cr_{ij} = (cr_{ij,1}, cr_{ij,2}, \dots, cr_{ij,ln})$ – the sequence of non-renewable resource amount required by activity O_{ij} :
 $cr_{ij,k}$ – the amount of the k -th resource required by the activity O_{ij} , $cr_{ij,1} \leq 0$; $k = 1, 2, \dots, ln$, $cr_{ij,k} = 0$ means the activity does not consume the k -th resource.

$Cw_{ij} = (cw_{ij,1}, cw_{ij,2}, \dots, cw_{ij,ln})$ – the sequence of amounts of non-renewable resources released by activity O_{ij} : $cw_{ij,k}$ – the amount of the k -th resource involved by activity O_{ij} , $cw_{ij,1} \geq 0$; $k = 1, 2, \dots, ln$; $cw_{ij,k} = 0$ means the activity does not engage the k -th resource.

$Tr_{ij} = (tr_{ij,1}, tr_{ij,2}, \dots, tr_{ij,ln})$ – the sequence of moments the determined amounts of subsequent non-renewable resources are required by activity O_{ij} :
 $tr_{ij,k}$ – the time counted since the moment s_{ij} the $dp_{ij,k}$ amount of the k -th non-renewable resource was released by the activity O_{ij} .

That is, assumed a resource is collected by activity during its execution: $0 \leq tr_{ij,k} < t_{ij}$; $k = 1, 2, \dots, ln$.

$Ts_{ij} = (ts_{ij,1}, ts_{ij,2}, \dots, ts_{ij,ln})$ – the sequence of moments the determined amounts of subsequent non-renewable resources are generated (released) by activity O_{ij} : $ts_{ij,k}$ – the time counted since the moment s_{ij} the $cw_{ij,k}$ amount of the k -th non-renewable resource was generated by the activity O_{ij} .

That is, assumed the resource is generated during activity execution, however, not earlier than the beginning of its collection, that is: $0 \leq ts_{ij,k} < t_{ij}$; $k = 1, 2, \dots, ln$, as well as $tr_{ij,k} \leq ts_{ij,k}$; $k = 1, 2, \dots, ln$.

NPV – the net present value used to measure a project's efficiency and calculated using the following formula:

$$NPV = \sum_{t=0}^n \frac{CF_t}{(1+k)^t} \quad (2)$$

where:

CF_t – 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].

Consequently, each activity O_{ij} is specified by the following sequences:

– starting times of activities in the activity network P_i :

$$S_i = (s_{i,1}, s_{i,2}, \dots, s_{i,loi}), 0 \leq s_{ij} < h, i = 1, 2, \dots, lp; j = 1, 2, \dots, lo_i,$$

– duration of activities in the activity network P_i :

$$T_i = (t_{i,1}, t_{i,2}, \dots, t_{i,loi}).$$

Elements of sequences: TP_{ij} , TZ_{ij} , DP_{ij} , Cr_{ij} , Cw_{ij} , Tr_{ij} , and Ts_{ij} specify the activity network P_i :

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

$$TP_{ij} = (tp_{i,1,j}, \dots, tp_{i,k,j}, \dots, tp_{i,loi,j}),$$

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

$$TZ_{ij} = (tz_{i,1,j}, \dots, tz_{i,k,j}, \dots, tz_{i,loi,j}),$$

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

$$TR_{ij} = (tr_{i,1,j}, \dots, tr_{i,k,j}, \dots, tr_{i,loi,j}),$$

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

$$TS_{ij} = (ts_{i,1,j}, \dots, ts_{i,k,j}, \dots, ts_{i,loi,j}),$$

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

$$DP_{ij} = (dp_{i,1,j}, \dots, dp_{i,k,j}, \dots, dp_{i,loi,j}),$$

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

$$CR_{ij} = (cr_{i,1,j}, \dots, cr_{i,k,j}, \dots, cr_{i,loi,j}),$$

– sequences of amounts of the j -th non-renewable resource involved by activities of the project P_i :

$$CW_{ij} = (cw_{i,1,j}, \dots, cw_{i,k,j}, \dots, cw_{i,loi,j}).$$

• Set of constraints – C

Given the project portfolio and available amounts of renewable and non-renewable resources as well as the above-mentioned sequences: T_i , TP_{ij} , TZ_{ij} , and DP_{ij} .

Given the time horizon $H = \{0, 1, \dots, h_{max}\}$, the project portfolio should be completed. That is, assumed the activities cannot be suspended during their execution, and moreover:

– each activity can request any kind and quantity (not exceeding the resource's limited amount) of any resource,

- each resource can be uniquely used by an activity,
- the quantity of renewable resource used by an activity cannot be changed or allotted to other activity,
- an activity can start its execution only if required amounts of renewable and non-renewable resources are available at the moments given by $Tp_{i,j}$ and $Ts_{i,j}$.

The project P_i is represented by activity-on-node networks, where nodes represent activities and arcs determine an order of activities' execution. Consequently, the following activity order constraints are considered [1, 2, 3]:

- the $O_{i,k}$ activity follows the $O_{i,j}$ -th one:

$$co^1_{i,k}: s_{i,j} + t_{i,j} \leq s_{i,k}, \quad (3)$$

- the $O_{i,k}$ activity follows other activities:

$$co^2_{i,k}: (s_{i,j} + t_{i,j} \leq s_{i,k}) \wedge (s_{i,j+1} + t_{i,j+1} \leq s_{i,k}) \wedge (s_{i,j+2} + t_{i,j+2} \leq s_{i,k}) \wedge \dots \wedge (s_{i,j+n} + t_{i,j+n} \leq s_{i,k}), \quad (4)$$

- the $O_{i,k}$ activity is followed by other activities:

$$co^3_{i,k}: (s_{i,k} + t_{i,k} \leq s_{i,j}) \wedge (s_{i,k} + t_{i,k} \leq s_{i,j+1}) \wedge (s_{i,k} + t_{i,k} \leq s_{i,j+2}) \wedge \dots \wedge (s_{i,k} + t_{i,k} \leq s_{i,j+n}). \quad (5)$$

Each activity $O_{i,k}$ should be finished before the h -th unit of time (h is the completion time of project portfolio P), that is, it should follow the constraint:

$$co^4_{i,k}: s_{i,k} + t_{i,k} \leq h \quad (6)$$

Constraints $co^1_{i,k}$, $co^2_{i,k}$, $co^3_{i,k}$, and $co^4_{i,k}$, encompassing relations existing among activities $O_{i,k}$ produce the set of precedence constraints

$$Co = \{co^1_{i,k}, co^2_{i,k}, co^3_{i,k}, co^4_{i,k}\}$$

Note that limited resource amounts may cause resource conflicts, that is, requiring the selection of relevant dispatching rules deciding the order of resources' allocation. In order to avoid such a conflict, the relevant constraints have to be taken into account. The set of conflict avoidance constraints $Cr = \{cr^1_{m,n,k}, cr^2_{m,n,k}\}$ introduced in [4, 5, 12] consists of:

$$cr^1_{m,n,k}: \sum_{i=1}^{lp} \sum_{j=1}^{lo_i} [dp_{i,j,k} \cdot \bar{l}(s_{m,n} + tp_{m,n,k}, s_{i,j} + tp_{i,j,k}, s_{i,j} + tz_{i,j,k})] \leq zo_{k,x_{m,n} + tp_{m,n} - 1} \quad (7)$$

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

where:

lp – the number of projects, lo_a – the number of activities in the project P_a ,

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

$1(u)$ – the unit step function

and

$$cr^2_{m,n,k}: \sum_{i=1}^{lp} \sum_{j=1}^{lo_i} [dp_{i,j,k} \cdot \bar{l}(vg_{k,d}, s_{i,j} + tp_{i,j,k}, s_{i,j} + tz_{i,j,k})] \leq zo_{k,vp_{k,d} - 1} \quad (8)$$

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

where:

$vg_{k,i}$ – the moments $vg_{k,i} \in H$ at which the available number of the k -th resource units is changed,

q – number of characteristic points.

Note that $Cr = \{cr^1_{m,n,k}, cr^2_{m,n,k}\}$ regards renewable resources. The similar ones should be considered in the case of non-renewable resources, for instance concerning the money. The set of conflict avoidance constraints $Cn = \{cn^1_{m,n,k}\}$ introduced in [4, 5, 12] consists of:

$$cn^1_{m,n,k}: zn_k - \sum_{i=1}^{lp} \sum_{j=1}^{lo_i} [cr_{i,j,k} \cdot 1(s_{m,n} - s_{i,j} - tr_{i,j,k})] + \sum_{i=1}^{lp} \sum_{j=1}^{lo_i} [cw_{i,j,k} \cdot 1(s_{m,n} - s_{i,j} - ts_{i,j,k})] \geq 0 \quad (9)$$

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

where:

lp – the number of projects, lo_a – the number of activities in the project P_a .

Finally, the considered set of constraints has the following form: $C = C_o \cup C_r \cup C_n$.

Therefore, the reference model considered can be seen as the constraint problem $CS = ((X, D), C)$. Consequently, depending on the questions stated the relevant context dedicated CSP can be considered. The standard questions can be formulated either in the straight or reverse way. So, the new problems can be aimed both at the determination of [8, 12, 13 and 16]:

- the criteria values implied by the assumed variables and constraints, for instance:

Do the given activities' times guarantee completion of the project portfolio within assumed time horizon H ?

- the variables guaranteeing expected values of the assumed goal functions, for example:

What are the beginning times T_i of activities guaranteeing the project portfolio completion time does not exceed a given time horizon H ?

The above questions belong to the class of so-called problems formulated in a reverse way, that is, problems our considerations are focused on. Some examples illustrating the above-mentioned two types of context dedicated CS are discussed in the section below.

3.2 Direct versus Reverse Approach

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

- a direct 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, resource amount, and their allocation to projects' activities?
 - Does a given resource allocation guarantee the production order makespan does not exceed the given deadline?

- Can the project portfolio be completed before an arbitrary given deadline?
- and so on.

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

- What activity duration times and resource amount guarantee the given POP makespan does not exceed the deadline?
- Does there exist resource allocation such that production order makespan does not exceed the deadline?
- Does there exist a set of activities' operation times guaranteeing a given project portfolio completion time will not exceed the assumed deadline?

The above-mentioned categories encompass the different reasoning perspectives, that is, deductive and abductive ones. The corresponding queries can be stated in the same model that can be treated as the composition of variables and constraints, that is, assumed sets of variables and constraints limiting their values. In that context, both an enterprise and the portfolio of 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.

What are the moments the activities starts their execution?

Given the following project portfolio, that is, the set of projects $P = \{P_1, P_2, P_3, P_4\}$. Activities $O_{i,j}$ of projects are specified by corresponding sets:

$$P_1 = \{O_{1,1}, \dots, O_{1,10}\}, P_2 = \{O_{2,1}, \dots, O_{2,12}\},$$

$$P_3 = \{O_{3,1}, \dots, O_{3,11}\}, P_4 = \{O_{4,1}, \dots, O_{4,13}\}.$$

The relevant activity networks [4, 12] are shown on the following figures: Figs 2–5.

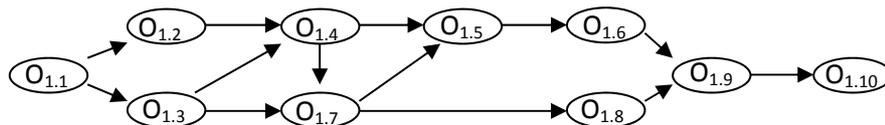
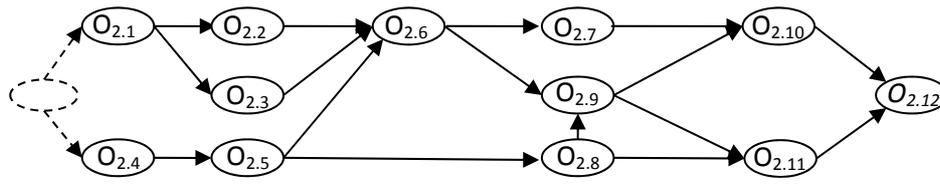
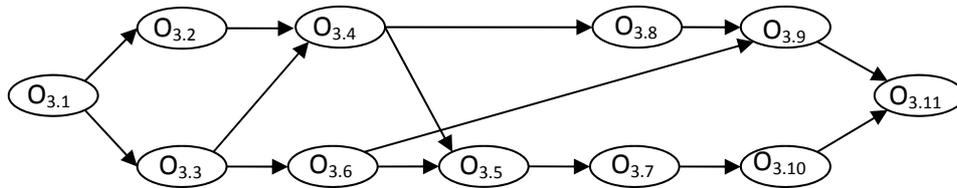
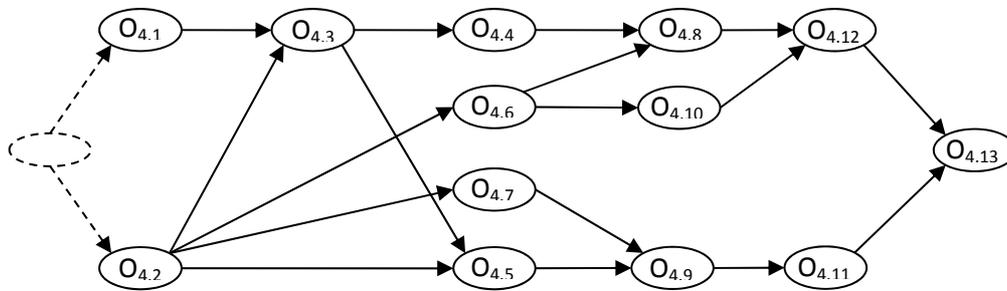


Figure 2. Activity network of the project P_1


 Figure 3. Activity network of the project P_2

 Figure 4. Activity network of the project P_3

 Figure 5. Activity network of the project P_4

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

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

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

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

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

Given are three kinds of renewable resources ro_1 , ro_2 , and ro_3 . Resource amounts are limited by the following

number of units: 11, 14, and 12, respectively. Resource amounts are constant in whole time horizon H . That is, assumed an amount of resources allocated to the activity at the moment of its beginning 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 , and P_4) activities are given in the following tables: Tables 1–4.

 Table 1. Amounts of resources required by the project P_1 activities (the sequences $DP_{1,1}$, $DP_{1,2}$, $DP_{1,3}$)

	$O_{1,1}$	$O_{1,2}$	$O_{1,3}$	$O_{1,4}$	$O_{1,5}$	$O_{1,6}$	$O_{1,7}$	$O_{1,8}$	$O_{1,9}$	$O_{1,10}$
$DP_{1,1}$	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 2. Amounts of resources required by the project P_2 activities (the sequences $DP_{2,1}$, $DP_{2,2}$, $DP_{2,3}$)

	$O_{2,1}$	$O_{2,2}$	$O_{2,3}$	$O_{2,4}$	$O_{2,5}$	$O_{2,6}$	$O_{2,7}$	$O_{2,8}$	$O_{2,9}$	$O_{2,10}$	$O_{2,11}$	$O_{2,12}$
$DP_{2,1}$	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 3. Amounts of resources required by the project P₃ activities (the sequences DP_{3,1}, DP_{3,2}, DP_{3,3})

	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 4. Amounts of resources required by the project P₄ activities (the sequences DP_{4,1}, DP_{4,2}, DP_{4,3})

	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

It is assumed that some activities besides renewable resources require non-renewable ones. Given are two kinds of non-renewable resources rn_1 and rn_2 . The 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 be used up and generate some number of resources

rn_1, rn_2 units. It is assumed that 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_{ij} and CW_{ij} , respectively, in the following tables: Tables 5–8

Table 5. Amount of used up (CR) and generated (CW) non-renewable resources required by activities of the project P₁ (the sequences CR_{1,1}, CR_{1,2}, CW_{1,1}, CW_{1,2})

	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
CW _{1,1}	3	2	0	2	4	4	2	0	2	4
CW _{1,2}	1	2	3	2	2	2	0	2	1	2

Table 6. Amount of used up (CR) and generated (CW) non-renewable resources required by activities of the project P₂ (the sequences CR_{2,1}, CR_{2,2}, CW_{2,1}, CW_{2,2})

	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
CW _{2,1}	3	2	0	2	1	2	0	2	0	2	0	1
CW _{2,2}	3	2	1	2	0	2	3	2	2	2	1	2

Table 7. Amount of used up (CR) and generated (CW) non-renewable resources required by activities of the project P₃ (the sequences CR_{3,1}, CR_{3,2}, CW_{3,1}, CW_{3,2})

	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
CW _{3,1}	2	3	2	0	2	1	2	2	2	3	2
CW _{3,2}	3	2	1	2	0	2	3	2	2	2	1

Table 8. Amount of used up (CR) and generated (CW) non-renewable resources required by activities of the project P₄ (the sequences CR_{4,1}, CR_{4,2}, CW_{4,1}, CW_{4,2})

	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
CW _{4,1}	2	3	2	0	2	1	2	2	2	3	2	3	2
CW _{4,2}	3	2	1	2	0	2	3	2	2	2	1	2	2

In the context of the above assumed data, that is, based on the requirements of the standard CS the following question is considered.

Q_1 : Does there exist a schedule following constraints assumed on availability of renewable and non-renewable resources and $NPV > 0$ such that the production order's completion time does not exceed the deadline H ?

Note that the schedule we are looking for is determined by moments $s_{i,j}$ the activities start their execution [4, 12].

The solution to the problem results in determination of moments the activities start their execution $s_{i,j}$. So, the solution we are searching for has the form of the following sequences:

$$S_1 = (s_{1,1}, \dots, s_{1,10}),$$

$$S_2 = (s_{2,1}, \dots, s_{2,12}),$$

$$S_3 = (s_{3,1}, \dots, s_{3,11}), \text{ and}$$

$$S_4 = (s_{4,1}, \dots, s_{4,13}).$$

Of course, the elements of sequences S_1 , S_2 , S_3 , and S_4 have to follow activities' order constraints from Figs 2–5 as well as constraints assumed for renewable (see Tables 1–4) and non-renewable (see Tables 5–8) resource allocation (guaranteeing deadlock avoidance). Constraints have a form similar to the formulas (3)–(9).

The question considered implies the relevant context dedicated CS.

Given

$$CS = ((X, D), C),$$

where:

- the set of decision variables X containing:
 - the input variables: $U = \{s_{1,1}, s_{1,2}, \dots, s_{1,l_01}, s_{2,1}, \dots, s_{p,l_0p}\}$;
 - the output variables: $Y = \{h, NPV\}$;
- the family of domains D , where the domains of variables T_i , $T_{p,i,j}$, $T_{z,i,j}$, $D_{p,i,j}$, $Cr_{i,j}$, $Cw_{i,j}$, $Tr_{i,j}$, and $Ts_{i,j}$ are determined by Tables 1–8, and variables corresponding to the beginning times of activities $s_{i,j} \in [0,50]$;
- the set of constraints C .

The considered problem CS and the question Q_1 can be specified in terms of newly stated problem CCS:

$$CCS = ((X, D), C \cup Cy),$$

where:

Cy – the set of output constraints corresponding to Q_1 : $Cy = \{cy_1, cy_2\}$,

$$cy_1: h \leq 40; cy_2: NPV > 0.$$

The result of CCS examination by the consistency-checking procedure is positive, so there exists the solution Vu following all the constraints $C \cup Cy$.

The results obtained from the OzMozart implemented procedure consists of the non-empty set of solutions Vu . Admissible values of considered variables $s_{i,j}$ have the following values:

$$S_1 = (0, 1, 1, 4, 11, 15, 8, 11, 23, 24),$$

$$S_2 = (0, 3, 7, 10, 13, 15, 20, 17, 23, 25, 25, 29),$$

$$S_3 = (0, 3, 3, 10, 17, 5, 19, 17, 20, 27, 31), \text{ and}$$

$$S_4 = (0, 0, 3, 5, 5, 3, 3, 13, 8, 6, 14, 16, 19).$$

The NPV index value calculated for projects: P_1 , P_2 , P_3 , P_4 follows the requirement $NPV > 0$, that is,

$$NPV_{P_1} = 0.3649,$$

$$NPV_{P_2} = 2.4775,$$

$$NPV_{P_3} = 1.3248, \text{ and}$$

$$NPV_{P_4} = 0.8134.$$

Therefore, the example presented illustrates the capability of an interactive multi-criteria project planning (e.g., taking into account a particular project deadline, project portfolio deadline, resource limits, and so on) approach to project prototyping issues. The problem of size just considered took less than 5 minutes (i.e., finding the first solution Vu ; the AMD Athlon(tm)XP 2500 + 1.85 GHz, RAM 1,00 GB platform has been used).

What are the times of activities' duration?

Given the following projects' portfolio, that is, the set of projects $P = \{P_1, P_2, P_3, P_4\}$ specified by the same activity networks (see Figs 2–5) and resource allocations (see Tables 2–9) as previously. However, the new time horizon $H = \{0, 1, \dots, 36\}$ is considered.

Given the projects' portfolio containing the following projects P_1 , P_2 , P_3 , and P_4 . The makespan admissible cannot exceed 36 units of time. Activities' operation times are not known; however constraints determining their execution constraints are given.

Table 9. Constraints linking activities $O_{i,j}$ execution times

	Constraint		Constraint
ct ₁	$t_{3,7} + t_{3,9} = 11$	ct ₆	$t_{3,3} + t_{3,4} = 9$
ct ₂	$t_{4,12} + t_{4,13} = 11$	ct ₇	$t_{2,3} + t_{2,4} = 9$
ct ₃	$t_{4,3} + t_{4,4} = 11$	ct ₈	$t_{2,3} + t_{2,4} = 9$
ct ₄	$t_{1,5} + t_{1,6} = 12$	ct ₉	$2t_{2,5} + t_{3,3} = 8$
ct ₅	$t_{1,9} + t_{1,10} = 7$	ct ₁₀	$2t_{4,1} + t_{2,8} = 12$

For instance, the following constraint: $t_{3,7} + t_{3,9} = 11$ means the activities' operation times are tightly linked, that is, increase of activity time associated with one operation (for example, $O_{3,7}$) results in a decrease of the other one (in this case $O_{3,9}$). The set of constraints considered is shown in Table 9.

Therefore, taking into account the above-mentioned assumptions the problem considered now reduces to the question:

Q₂: What values and of what variables $T_1, T_2, T_3,$ and T_4 guarantee the makespan of the projects' portfolio does not exceed a given deadline subject to limits imposed on available amounts of renewable and non-renewable resources as well as $NPV > 0$?

In order to respond to this question, the values of the following sequences are sought:

$$T_1 = (t_{1,1}, \dots, t_{1,10}),$$

$$T_2 = (t_{2,1}, \dots, t_{2,12}),$$

$$T_3 = (t_{3,1}, \dots, t_{3,11}),$$

$$T_4 = (t_{4,1}, \dots, t_{4,13})$$

and

$$S_1 = (s_{1,1}, \dots, s_{1,10}),$$

$$S_2 = (s_{2,1}, \dots, s_{2,12}),$$

$$S_3 = (s_{3,1}, \dots, s_{3,11}),$$

$$S_4 = (s_{4,1}, \dots, s_{4,13}).$$

Taking into account the data assumed, consider the following formulation of the relevant CCS. Given $CS = ((X, D), C)$, where:

- the set of decision variables X , containing:
 - the input variables: $U = \{ t_{1,1}, t_{1,2}, \dots, t_{1,l_01}, t_{2,1}, \dots, t_{lp,l_0lp}, s_{1,1}, s_{1,2}, \dots, s_{1,l_01}, s_{2,1}, \dots, s_{lp,l_0lp} \}$,
 - the output variables: $Y = \{h, NPV\}$;
- the family of domains D , where the domains of variables $T_i, T_{p,i,j}, T_{z,i,j}, D_{p,i,j}, Cr_{i,j}, Cw_{i,j}, Tr_{i,j}$, and $Ts_{i,j}$ are determined by Tables 1–8, and variables

- corresponding to the beginning times of activities $s_{i,j} \in [0,50]$, and variables corresponding to activities' duration times $t_{i,j} \in [1,15]$;
- the set of constraints $C \cup \{ct_1, ct_2, \dots, ct_{10}\}$ (following Table 9).

The considered problem CS and the question Q_2 can be specified in terms of CCS :

$$CCS = ((X, D), C \cup Cy),$$

where:

Cy – the set of output constraints corresponding to Q_1 :
 $Cy = \{cy_1, cy_2\}$, $cy_1: h \leq 36$; $cy_2: NPV > 0$.

The result of CCS examination by the consistency-checking procedure is positive, so there exists the solution Vu following all the constraints $C \cup Cy$. The results obtained from the $OzMozart$ implemented procedure consists of the non-empty set of solutions Vu . The first admissible solution has been obtained in 250 s. So, the sequences of obtained activities' operation times are as follows:

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

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

$$T_3 = (3, 7, 4, 5, 2, 1, 6, 3, 5, 4, 8), \text{ and}$$

$$T_4 = (3, 3, 2, 5, 6, 1, 4, 1, 8, 4, 3, 5, 6).$$

In turn, the sequences of the moments of activities beginning are as follows:

$$S_1 = (0, 1, 1, 4, 11, 17, 8, 11, 23, 26),$$

$$S_2 = (0, 3, 8, 10, 13, 15, 20, 15, 21, 23, 23, 27),$$

$$S_3 = (0, 3, 3, 10, 15, 7, 17, 15, 18, 23, 27), \text{ and}$$

$$S_4 = (0, 0, 3, 5, 5, 3, 3, 10, 11, 4, 11, 19, 24).$$

The NPV index value calculated for projects: $P_1, P_2, P_3,$ and P_4 follow the requirement $NPV > 0$, that is,

$$NPV_{P_1} = 0.262,$$

$$NPV_{P_2} = 2.386,$$

$$NPV_{P_3} = 0.86, \text{ and}$$

$$NPV_{P_4} = 1.339.$$

The introduced CP-based reference model provides a formal framework allowing one to formulate project portfolio planning problems in direct and reverse ways. In other words, it provides a base for designing interactive task oriented decision support tools. This offers the possibility of responding to questions such as: What values and of what variables guarantee the production orders will be completed due to assumed values of performance indexes? (besides such standard questions as: What is the project portfolio completion time?).

The main idea behind this approach lies in searching for the conditions guaranteeing the existence of responses to the standard queries as well as for conditions guaranteeing the employed search strategies can be used in online mode for the given size of project planning problems. Therefore, the reference model of decision problems can be seen as a knowledge base kernel of a methodology aimed at designing dedicated and interactive decision support systems.

4 DSS for Production Order Portfolio Scheduling

In multi-project planning, the main focus is on deciding on a schedule for all activities of projects and allocating resources in order to finish projects before their deadlines. One of our objectives is to propose a method that allows generating a schedule for the execution of a set of orders with resource allocation for a given period of time, guaranteeing a solution meeting a set of enterprise specific goals. Furthermore, due to the fact that unpredicted circumstances frequently happen during the execution of orders, it is required to control them in an online mode in order to quickly react to these circumstances. Among the activities of online control, rescheduling the activities of multiple projects and reallocating resources are critical. Therefore, another of our objectives is to develop a method for rescheduling the project portfolio and reallocating resources with the consideration of budget, cash flow, resource capacity, new projects, and so on.

4.1 Structure and Functioning

It seems obvious, that not all behaviors (functionalities) are reachable under constraints imposed by a given system's structure. The similar observation concerns the system's behavior that can be achieved in systems

possessing specific structural constraints. So, since system constraints determine its behavior, both the system structure and the desired behavior have to be considered simultaneously. In that context, our contribution provides a discussion of some solubility issues concerning structural properties providing conditions guaranteeing assumed system behavior (straight problem formulation) as well as behavioral requirements imposing conditions that have to be satisfied by system structure (reverse problem formulation).

Regardless of the character and scope of business activities, a modern enterprise has to build a project-driven development strategy in order to respond to challenges imposed by growing complexity and globalization. Managers need to be able to utilize a modern DSS so as to undertake optimal business decisions in a further strategic perspective of enterprise operations.

The idea behind an interactive interface module employs a navigation multi-board concept shown in Fig. 6. Its solution assumes hybridization of *Drag and Drop*, *Touch Screen Panel*, and *Virtual Table* technologies. The menu composed of a set of tabs and folders allows one to specify parameters and decision variables describing both the enterprise's capability (e.g., following from its structure and possible ways of work flow organization) and requirements imposed by production orders at hand (determining, for instance, the batch size, production cycles, work in progress, and so on).

Dependent on the kind of decision problem considered, the relevant tabs are selected and structured on the board so as to encompass one of the following problem formulations:

- a straight planning problem (e.g., Is it possible to undertake the given project portfolio under a given resource availability while guaranteeing disturbance-free execution of activities?);
- a reverse planning problem (e.g., Which values of system parameters guarantee that the project portfolio at hand will be completed while following constraint assumed performance index values?);

Note that in the course of interactive solution search, any change in parameters describing:

- an enterprise – results in different values of criteria matching-up production order requirements;
- the criteria specifying production order requirements – results in suggestion of an enterprise structure change.

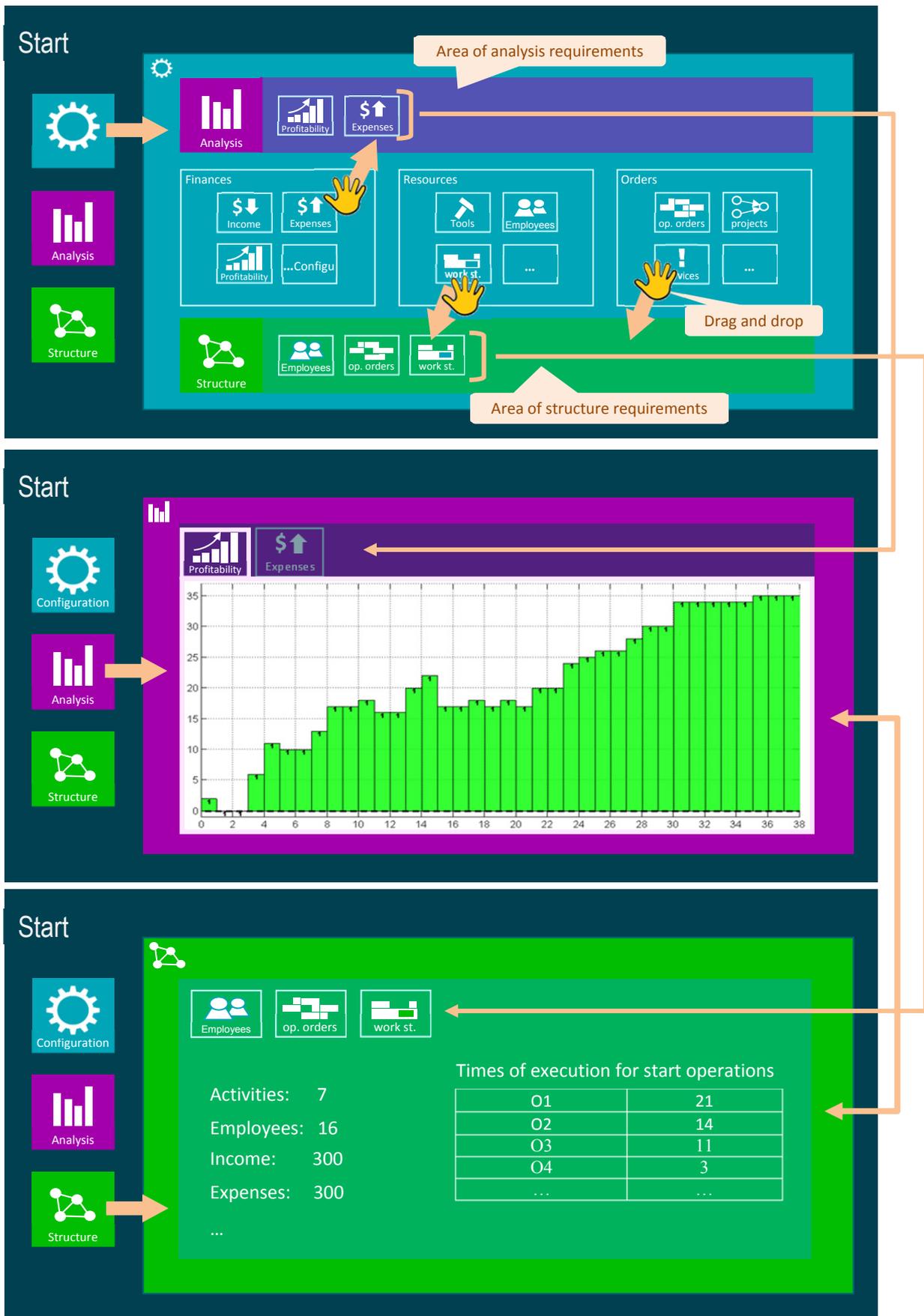


Figure 6. Exemplary multi-board interface configuration composed of folders and/or directories used in the course of decision problem formulation/solution

4.2 Customized oriented production flow scheduling

A production system is given in which a set of projects (the POP) has to be executed. The state of the system encompasses its resource allocation to projects planned for execution. Traditionally stated multi-criteria planning problems formulated as direct ones address standard questions such as: Is it possible to undertake the given project portfolio under a given resource availability while guaranteeing disturbance-free execution of activities? Such a formulation, however, may lead to rejecting projects, which could actually be approved by the system if a satisfactory solution could be found by changing the levels of constraints.

In order to illustrate how it is possible to cope with this kind of problems, let us consider a multi-product job shop where POP Z^1 aimed at device A manufacturing is processed. The device should be completed within the time period $\tau^1 = [360, 420]$ minutes. Consider two newly submitted POPs Z^2 and Z^3 containing the unique production orders Z_1^2 and Z_1^3 , respectively. The activity

networks encompassing activities orders in the considered POPs are shown in Fig. 7. The possible assignment of activities and their duration times are collected in Table 10. Distinguished activities can be executed on shared resources m_1 - m_7 . The resources m_7 and m_1 can replace each other, that is, lead to alternative scenarios. The following question is considered: Is it possible to complete devices B and C following the portfolios Z^2 and Z^3 within arbitrary, assumed time periods $\tau^2 = [420, 480]$ and $\tau^3 = [250, 300]$ minutes, respectively?

For the aforementioned data, implemented in CP language OzMozart (Dual Core 2.67 GHz, 2.0 GB RAM), the only admissible solution (admissible schedule $X = \{X^1, X^2, X^3\}$) is shown in Fig. 8; it means the considered devices A, B, and C can be completed within the assumed time periods, that is, τ^1 , τ^2 , and τ^3 , respectively. Due to the implemented scenario, four activities among 28 others have to be realized on resource m_7 instead of m_1 . The calculation time required by each scenario is equal to 2 s.

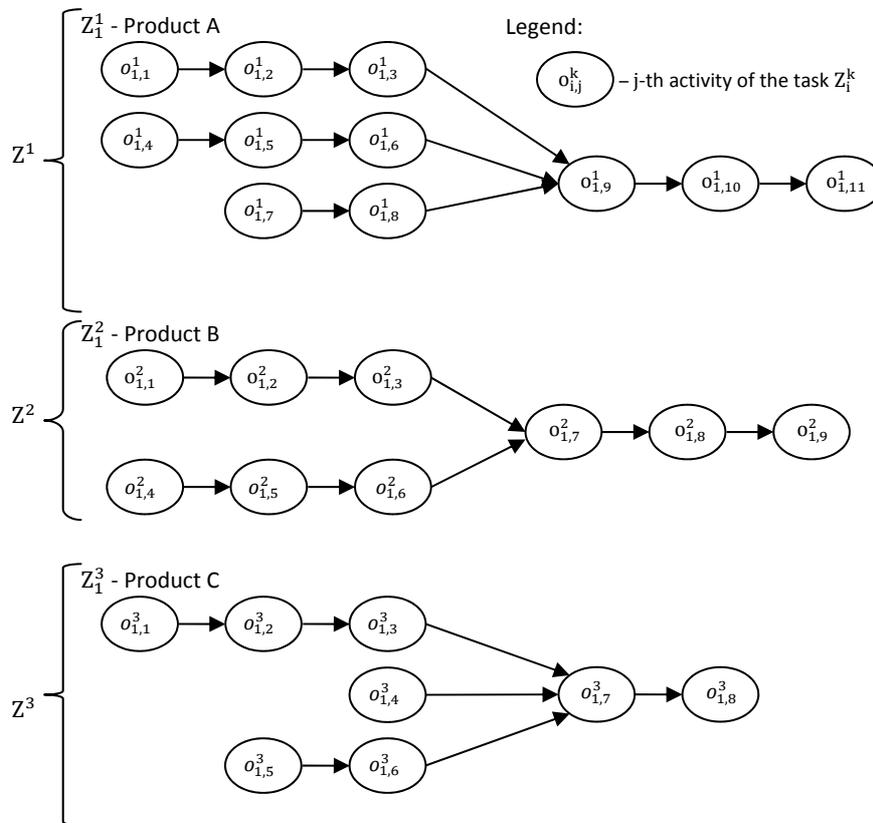


Figure 7. Activity networks associated with devices A, B, and C

Table 10. Alternative allocations for activities and their duration times

Tasks	Activities	Variants	Resources	Time [min]
Z_1^1	$O_{1,1}^1$	$^1S_{1,1}^1$	m_5	30
	$O_{1,2}^1$	$^1S_{1,2}^1$	m_1	50
		$^2S_{1,2}^1$	m_7	30
	$O_{1,3}^1$	$^1S_{1,3}^1$	m_2	50
	$O_{1,4}^1$	$^1S_{1,4}^1$	m_5	30
	$O_{1,5}^1$	$^1S_{1,5}^1$	m_1	50
		$^2S_{1,5}^1$	m_7	50
	$O_{1,6}^1$	$^1S_{1,6}^1$	m_2	50
	$O_{1,7}^1$	$^1S_{1,7}^1$	m_5	30
	$O_{1,8}^1$	$^1S_{1,8}^1$	m_3	30
	$O_{1,9}^1$	$^1S_{1,9}^1$	m_1	30
$^2S_{1,9}^1$		m_7	50	
$O_{1,10}^1$	$^1S_{1,10}^1$	m_2	50	
$O_{1,11}^1$	$^1S_{1,11}^1$	m_1	50	
	$^2S_{1,11}^1$	m_7	30	
Z_1^2	$O_{1,1}^2$	$^1S_{1,1}^2$	m_5	30
	$O_{1,2}^2$	$^1S_{1,2}^2$	m_4	30
	$O_{1,3}^2$	$^1S_{1,3}^2$	m_3	30
	$O_{1,4}^2$	$^1S_{1,4}^2$	m_5	50
	$O_{1,5}^2$	$^1S_{1,5}^2$	m_1	90
		$^2S_{1,5}^2$	m_7	50
	$O_{1,6}^2$	$^1S_{1,6}^2$	m_2	130
	$O_{1,7}^2$	$^1S_{1,7}^2$	m_1	30
		$^2S_{1,7}^2$	m_7	30
	$O_{1,8}^2$	$^1S_{1,8}^2$	m_2	50
	$O_{1,9}^2$	$^1S_{1,9}^2$	m_1	50
$^2S_{1,9}^2$		m_7	130	
Z_1^3	$O_{1,1}^3$	$^1S_{1,1}^3$	m_1	80
		$^2S_{1,1}^3$	m_7	50
	$O_{1,2}^3$	$^1S_{1,2}^3$	m_5	30
	$O_{1,3}^3$	$^1S_{1,3}^3$	m_3	30
	$O_{1,4}^3$	$^1S_{1,4}^3$	m_1	50
		$^2S_{1,4}^3$	m_7	30
	$O_{1,5}^3$	$^1S_{1,5}^3$	m_2	50
	$O_{1,6}^3$	$^1S_{1,6}^3$	m_1	50
		$^2S_{1,6}^3$	m_7	70
	$O_{1,7}^3$	$^1S_{1,7}^3$	m_4	50
$O_{1,8}^3$	$^1S_{1,8}^3$	m_1	30	
	$^2S_{1,8}^3$	m_7	50	

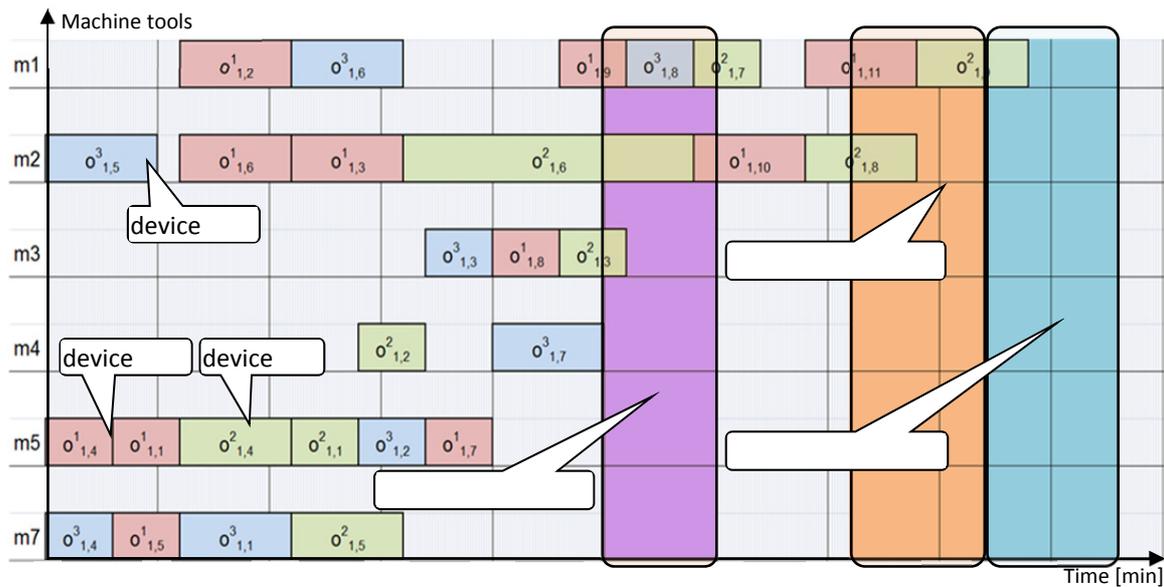


Figure 8. Gant's chart (schedule $X = \{X^1, X^2, X^3\}$) of production order portfolio execution

5 CONCLUSIONS

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

Better planning, in the manner supported by the proposed approach, can improve companies' competitiveness through satisfying budgetary constraints and improving utilization of resources from a cash-flow perspective. A computer implementation of the proposed methodology should provide a new generation DSS supporting one in cases of online resource allocation and task scheduling as well as production order batching and routing. Such a tool should be especially helpful when actually the processed products' portfolios do not spend all the company's capability reserves, that is, there is a room for additional work order considerations.

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THE DECOMPOSITION PROCESS OF INSURANCE OPERATIONS

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Abstract: This study sets out an original concept of the decomposition process of insurance operations. The first part of the paper presents the concept of the process, the process-based approach and process management. The further part identifies the processes carried out in insurance companies and discusses the purposes of implementing them. The final part of the study presents an example of the practical application of the process-based approach to issues of financial management of an insurance company.

Keywords: process, process-based approach, process management.

1 Introduction

Insurance companies are an important part of the financial market, which is now facing an ever more competitive struggle, and a need for more and more risk protection. The activities of insurance companies in these conditions require a new approach. This study assesses that the process-based approach to insurance activity is adequate for the conditions for changes in the insurance business environment. It provides for consistent foundations for many observations on the financial management of insurance companies; it enables the decision-making processes to be tracked, to monitor the legitimacy of costs incurred; it sets out conditions for generating accurate and important – both strategically and operationally – cost information, including on the processes and activities undertaken.

2 Processes, process-based approach and process management

The functioning of any organisation can be presented by showing a group of interrelated processes, organisation, while minimising the operating costs of these processes. This approach offers the greatest potential for improving the effectiveness and cooperation between organisational units pursuing the process, and enables the whole organisation to function more efficiently [1, pp. 14-15]. The literature reveals a number of definitions of the concept of process. T. Pszczołkowski defines a process ‘as a series or a range of events occurring in time and treated as a whole due to certain distinctive features’ [12, p. 185]. According to J. Zieleniewski, ‘a process is many consecutive events that are interdependent in some way’ [16, p. 16]. According to M. Porter, ‘a process is a val-

ue chain in which the amount involved in the creation or delivery of a product or service increases through the implementation of various activities. Each subsequent activity performed in the process should be adding a new value to the effect of prior activities’ [11, p. 3]. According to P. Grajewski, ‘a process is a set of sequential steps that are interrelated with cause-effect relationships. The results of the preceding actions are the input of the subsequent ones. Every action or set of actions can be described as a process by which a certain initial value (effort) brings about a result (volume converted, enriched with added value), which is the result of the process’ [5, p. 55]. M. Trocki, M. Romanowska define processes ‘as sets of activities implemented in the organisation in cause-effect relationships, carried out to achieve the pursued objective by teams of performers at many workplaces, in many organisational units’ [13, p. 64]. J. Brilman defines a process ‘as a set consisting of a sequence of operations performed to achieve pre-determined results’ [2, p. 287]. According to E. Skrzypek and M. Hofman ‘a process is a logical sequence of consecutive or concurrent actions, the implementation of which leads to meeting customer expectations, both internal and external, by providing him with a product, service or documentation in accordance with his requirements’ [14, p. 12]. K. Perechuda defines a process ‘as a set of concurrent tasks running in parallel, conditionally or sequentially, leading to changes in the assets of a company from the input to the final results in the form of a product or service’ [10, p. 88].

Gathering from the above definitions, the authors most often define a process as a sequence of actions (operations) performed in parallel or sequentially, conditionally, which aim to produce a product or service.

Table 1. Differences between the traditional and the process-based approach to business management
(source: [13, pp. 10 – 11])

Characteristics	Static aspect	Dynamic aspect
Term	Structural Management	Process Management
Elementary management objects	Workplaces	Work operations
Complex management objects	Organisational units as a grouping of work positions: lines, sections, branches, units, divisions, offices, levels, departments	Processes as a grouping of operations: phases of processes, partial processes, processes, complexes of processes
Component of management	Functions as groupings of repetitive tasks, people as employees of organisational units, resources as resources of organisational units	Tasks as a series of actions, people as participants in the processes, resources as means of process implementation

At the same time, they emphasise the need to meet the internal and external expectations of the customer, as well as indicate the need for order, to organise activities in time and space.

Targeting an organisation (a company, an institution) towards the processes occurring in it is called the process-based approach or orientation. This approach assumes that each entity is a set of mutually interwoven processes, whose identification allows a better understanding of value creation, where streamlining and continuous improvements increase the effectiveness of the enterprise and customer satisfaction [9, p. 40].

A process-based approach to managing business organisations (process-based management) is currently the dominant paradigm in management. It is characterised by changing from the classic perception of the organisation, which is based on the logic of specialisa-

tion and grouping similar functions to try and create larger units i.e., changing into a new organisation focused on gathering resources from various areas around building value for their customers. In this approach, the processes are the basis for the allocation of tasks, resources, for development, training, evaluation and rewarding of employees [1, p. 17].

Differences between the traditional and the process-based approach to business management are shown in Table 1.

Process management is defined as a comprehensive and systematic continuous use of influence concepts, methods and tools of influence on the processes taking place in the organisation, aimed at achieving the goals of the organisation and best meeting the needs of its external and internal customers [9, p. 57]. A process management diagram is shown in Fig. 1.

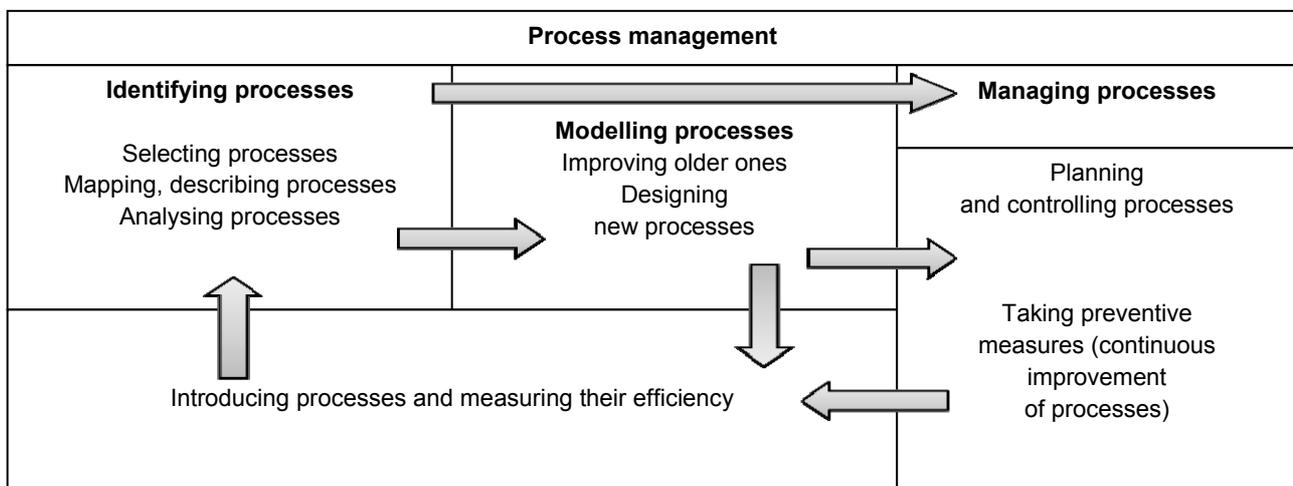


Figure 1. A process management diagram
(source: [8, p. 186])

The aim of process management is to:

- reduce the duration of processes,
- reduce costs of processes,
- increase the quality of the processes and of products/services,
- increase the productivity of employees,
- strengthen the competitive advantage.

The idea of process management has many advantages, among which can be mentioned:

- it is better than the conventional description of the organisation's activities,
- a greater ability to assess and influence the effectiveness of the entire organisation, in particular its clearly separated parts of processes,
- the process description of the organisation makes it easier for the employees to explore the operation (the reference process) with a parallel, optimistic prospect of their own impact on the results achieved,
- greater predictability of behaviour of employees strongly motivated to achieving results in all areas of the organisation's activities, and not only in those that are verified by external customers' expectations,
- a potentially big opportunity to reduce the cost of the organisation's activities through very flexible

forms of using all the resources of the organisation, including human resources,

- a significantly higher level of operational flexibility than in a functionally, classically configured organisation – achieved by the high level of responsiveness to expectations of customers,
- a potentially positive impact of the process-based organisational system on the learning and the development of both employees and the entire organisation [1, p. 39].

The entry point for process management is to identify the processes to determine what processes are needed in the organisation so that customers receive the expected product/service. For each process, there should be targets set for its implementation, taking into account the objectives of the organisation as well as customers' requirements.

3 The concept of insurance business process decomposition

The purpose of the business of insurance is to provide specific insurance related to the offering and granting protection against the risk of the effects of random events [15, Art. 3 point 1]. The activities of insurance companies as well as of other organisations operating in a competitive market is focused on the customer's needs and satisfaction, as shown in Fig. 2.

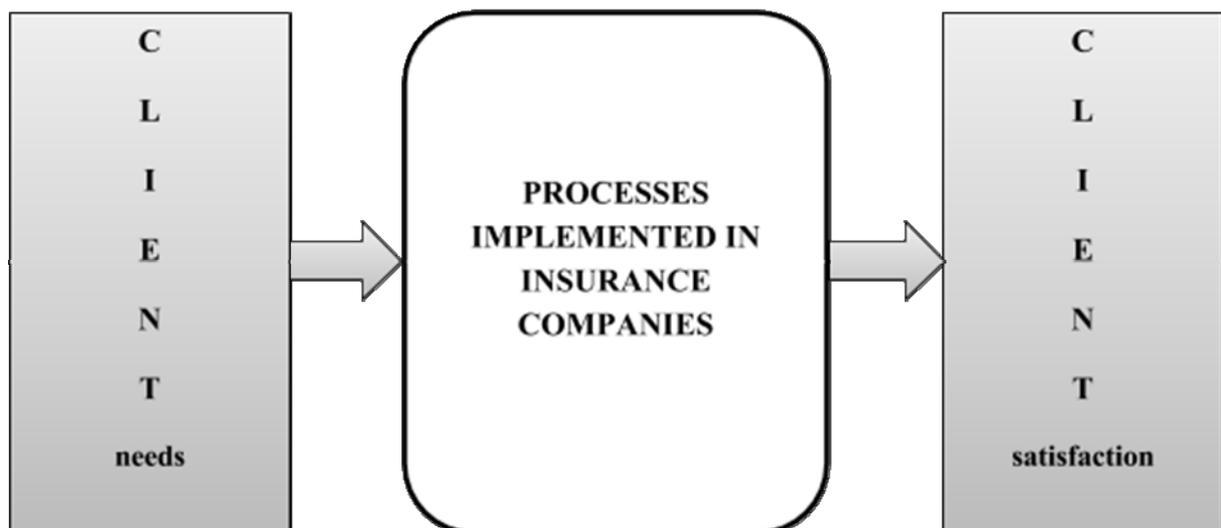


Figure 2. Market orientation of insurance companies
(source: [4])

The issues of a process-based approach to the business of insurance are usually neglected in the numerous publications on insurance. The only exceptions are the works of A. Karmańska [6], A. Karmańska, K. Kędziora and M. Lament [7] and L. Gąsiorkiewicz [3, 4]. A. Karmańska, for the purposes of modelling the activity-based costing, singled out the following processes carried out in the framework of the insurance business:

- marketing,
- sales of insurance products,
- reinsurance of insured risk,
- management of insurance fund deposits,
- process of compensation or benefits and recourse proceedings,
- preventive process,
- administering the collections of insurance statistics,
- process of managing finance,
- human resource management,
- managing insurer's infrastructure and regional network.

Then, the author presents a functional map of the decomposition of the insurance company, highlighting the first, second and third degree processes and auxiliary processes. According to A. Karmańska, the insurer is justified to use the gradation of operational processes and singling out processes at the interface between the insurer, the customer, and the processes in the background of this relationship.

First-degree (primary) processes include:

- marketing,
- selling insurance products,
- compensation.

Second degree (secondary) processes include:

- insured risk reinsurance,
- insurance company's investment management,
- prevention,

while third degree processes include:

- administering the collections of insurance statistics.

The auxiliary processes are: human resource management, financial management, and managing the regional network.

A. Karmańska, K. Kędziora, M. Lament - for the needs of financial accounting, distinguish the following processes:

- sales of insurance products,
- compensation and benefits and recourse proceedings,
- reinsuring insured risks,
- managing the insurance company's investments,
- financial management.

The processes highlighted by the authors are part of the processes listed by A. Karmańska, and the sub-processes are identical. The authors do not specify in their work the criteria according to which they made the division of the processes.

According to the author of this study, the processes carried out at insurance companies can be divided into three groups, namely: the primary, secondary and the management (general) processes. The primary processes are those related to the primary task of insurance companies, as specified in the Insurance Activity Act (providing insurance cover). These include insurance agreements and – in case of occurrence of an event specified in the contract – the liquidation of damages.

Secondary processes are processes that support the implementation of the primary processes. Thanks to this support, the primary processes can produce the expected results. 'The products' of these processes are often not visible to external clients, but have a significant impact on the financial management of insurance companies.

Management (general) processes are processes designed to ensure the effective planning and operation of the primary and secondary processes, and the effective management of the insurance company.

A decomposition of the processes carried out in the insurance companies is presented in Fig. 3.

The objectives of the insurance business processes are presented in Table 2.

The decomposition process of insurance business:

- is better than the conventional description of the organisation's activities,
- gives a greater ability to assess and influence the effectiveness of the entire organisation, in particular its clearly separated parts of processes,
- makes it easier for the employees to explore the operation (the reference process) with a parallel, optimistic prospect of their own impact on the results achieved,

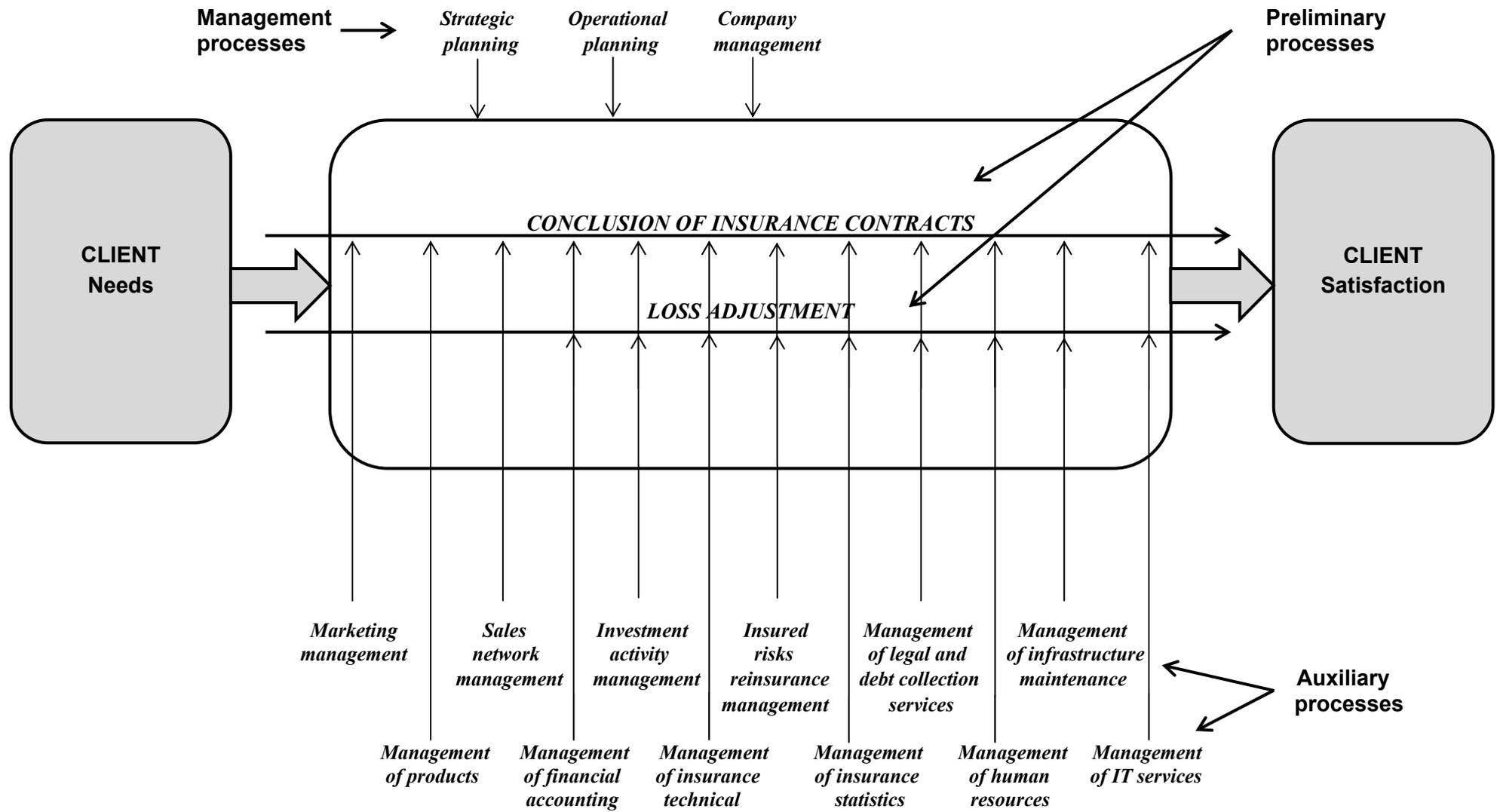


Figure 3. Insurance business processes and their mutual interdependencies
(source: own study)

Table 2. The objectives of the insurance business processes
(source: own study)

Process	The objective of the process
Conclusion of insurance contracts	Acquiring a premium from current and future customers in accordance with the strategic objectives of the insurance company
Loss adjustment	Deciding the scope of liability, and the amount of compensation adequate to the extent of the damage, in accordance with the requirements of laws and internal regulations of the insurance company and the settlement of claims ending with the payment of compensation / benefits due
Marketing management	Planning and implementing marketing activities to support the implementation of the sales and image building objectives of the insurance company.
Product management	Optimisation of the product offer tailored to the current and future needs of customers, according to the strategic objectives of the insurance company
Managing the sales network	Organisation and maintenance of an optimal insurance products sales network
Financial accounting	Providing timely and correct records of business events, as well as providing financial reporting and the timely payment of financial obligations of the insurance company
Investment activity (investment deposits)	Achieving a high return on investment at a given level of risk, taking into account the need to ensure the liquidity of cash
Technical provisions	Financial security of current and future liabilities of the insurance company toward customers arising from insurance contracts
Reinsurance of insured risks	Ensuring the financial security of the insurance company by dispersing the insurance risk (increasing the insurance capacity, the stabilising the performance of the insurance company and protecting against catastrophic risk)
Insurance statistics	Creating an internal system of reporting on insurance activities
Legal support and debt collection services	Ensuring uniform principles of legal support and debt collection services of the company and its regional units
Human resource management	Selection of employees with optimal qualifications for the position and for the implementation of an incentive and remuneration policy of the insurance company
Information technology support	Needs analysis and implementation of projects and maintenance of the IT infrastructure of the insurance company
Infrastructure maintenance	Needs analysis and securing the fixed assets and insurance forms necessary for the operations of the insurance company

- allows an opportunity to reduce the cost of the organisation's activities through very flexible forms of using all the resources of the organisation, including human resources,
- provides a significantly higher level of operational flexibility than in a functionally, classically configured organisation – achieved by the high level of responsiveness to expectations of customers,
- brings a better understanding of the processes of decision-making in the financial management of insurance companies.

A further part of the paper presents the cash flows using the example of one of the primary processes, namely the process of concluding insurance contracts.

4 Analysis of financial flows in the process of concluding insurance contracts

The process of concluding insurance contracts, from the point of view of financial management, can be broken down the following actions, as shown in Fig. 4.

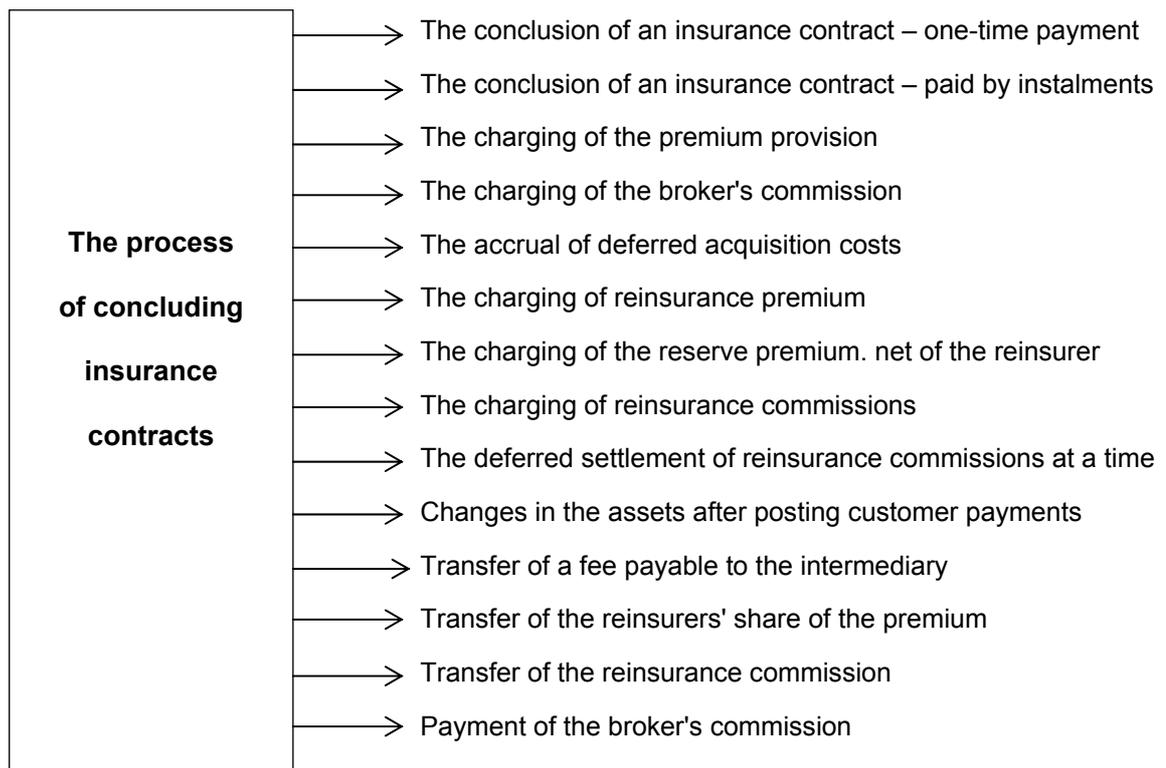


Figure 4. Activities carried out in the process of concluding insurance contracts
(source: own study)

The process of concluding insurance contracts has a multi-directional impact on the financial performance of insurance companies. This applies both to activities carried out in the process, as well as to the costs associated with the implementation of the process. The values of assets and liabilities change, as do the positions of the insurance technical account and of the profit and loss account. This causes changes in the financial performance of insurance companies. A model of financial flows in the process of concluding insurance contracts is shown in Fig. 5.

Legend:

- 1 - the conclusion of an insurance contract – a one-time payment,
- 2 - the conclusion of an insurance contract – payment by instalments,
- 3 - the charging of the premium provision,
- 4 - the charging of the broker's commission,
- 5 - the accrual of the deferred acquisition costs,
- 6 - the charging of the reinsurance premium (proportional reinsurance),
- 7 - the charging of the reserve premium, net of the reinsurer,
- 8 - the calculation of the reinsurance commissions,
- 9 - the deferred settlement of reinsurance commissions at a time,
- 10 - the costs of implementing the process of concluding insurance contracts,
- 11 - posting customer payments,
- 12 - transfer of a fee payable to the intermediary,
- 13 - transfer of the reinsurers' share of the premium,
- 14 - transfer of the reinsurance commission,
- 15 - payment of the broker's commission,
- 16 - transfer of the technical result to the general profit and loss account,
- 17 - transfer of net profit (loss) attributable to the liabilities.

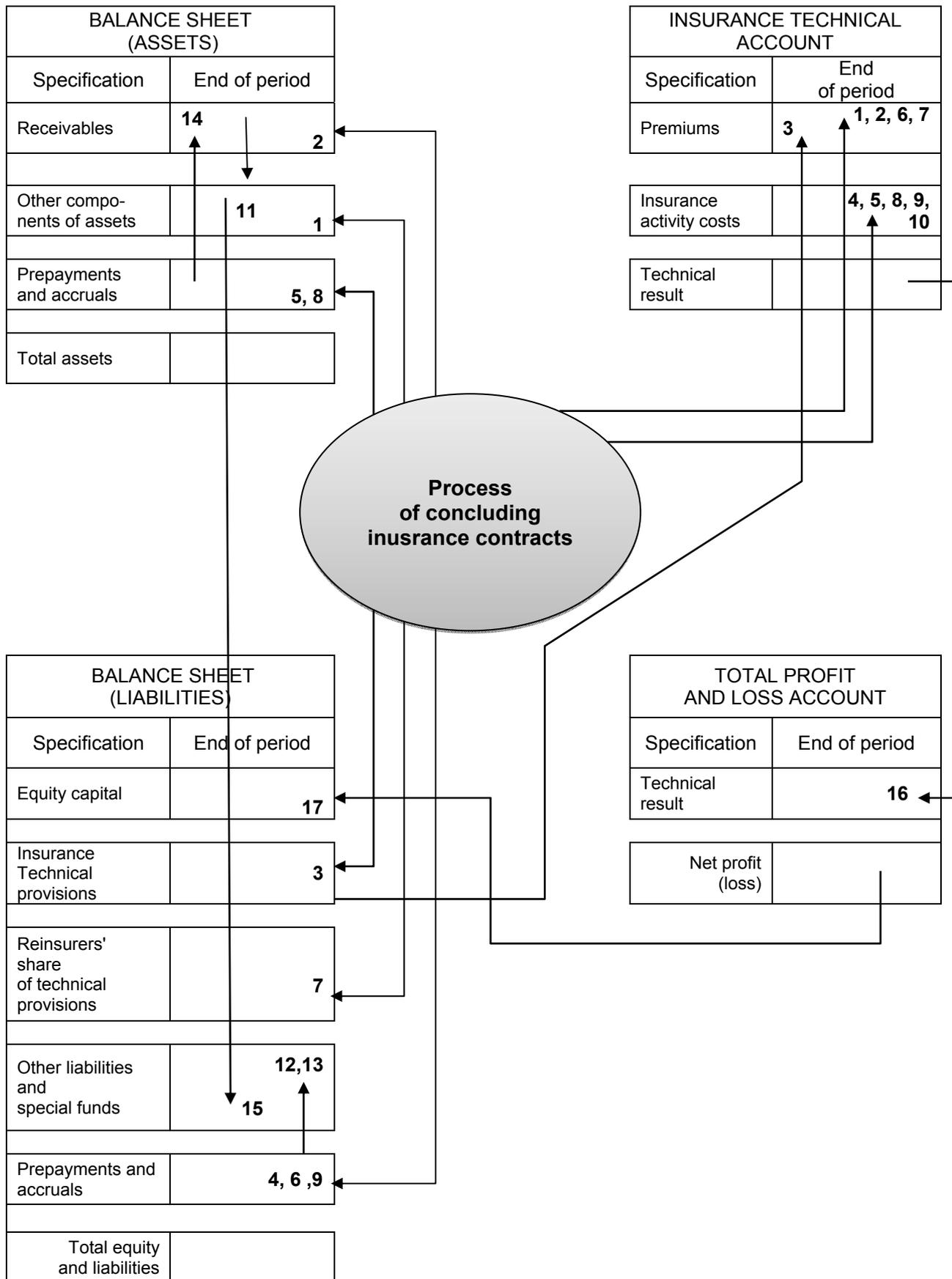


Figure 5. Model of financial flows in the process of concluding insurance contracts (source: [4])

Table 4. The impact of the activities carried out in the process of concluding insurance contracts on the formation of the balance sheet, the insurance technical account and the general profit and loss account
(source: own study)

Activity	Balance sheet	Insurance technical account	General profit and loss account
The conclusion of an insurance contract – a one-time payment	Raises the sum of assets and liabilities	Improves the technical result	Improves earnings
The conclusion of an insurance contract – payment by instalments	Raises the sum of assets and liabilities	Improves the technical result	Improves earnings
The charging of the premium	It does not change the total assets and liabilities	Worsens the technical result	Worsens earnings
The charging of the broker's commission	It does not change the total assets and liabilities	Worsens the technical result	Worsens earnings
The accrual of deferred acquisition costs	Raises the sum of assets and liabilities	Improves the technical result	Improves earnings
The charging of reinsurance premium	It does not change the total assets and liabilities	Worsens the technical result	Worsens earnings
The charging of the reserve premium, net of the reinsurer	It does not change the total assets and liabilities	Improves the technical result	Improves earnings
The charging of reinsurance commissions	Raises the sum of assets and liabilities	Improves the technical result	Improves earnings
The deferred settlement of reinsurance commissions at a time	It does not change the total assets and liabilities	Worsens the technical result	Worsens earnings
Changes in the assets after posting customer payments	Assets items are changed without changing the total assets	They do not change the technical result	No change in earnings
Transfer of a fee payable to the intermediary	Changes liability items without changing the total liabilities	It does not change the technical result	No change in earnings
Transfer of the reinsurers' share of the premium	Changes liability items without changing the total liabilities	It does not change the technical result	No change in earnings
Transfer of the reinsurance commission	Assets items are changed without changing the total assets	It does not change the technical result	No change in earnings
Payment of the broker's commission	Reduces the total assets and liabilities	It does not change the technical result	No change in earnings

The impact of the activities carried out in the process of concluding insurance contracts on the formation of the balance sheet, the insurance technical account and the general profit and loss account is presented in Table 4.

The analysis of financial flows, of a sample process shows that the decomposition process of insurance business creates conditions that significantly improve

the monitoring of the financial situation of an insurance company. It enables a thorough analysis of the impact of individual processes – and activities implemented as part of them – on the financial results of insurance companies and enables appropriate actions to be taken in this regard.

5 Conclusion

The use of a process-based approach results in the perception of the insurance company as a dynamic organisation with a number of processes aimed at achieving certain objectives. This perception of insurance companies can improve the efficiency and effectiveness of their actions and also fosters:

- the transparency of the insurance company,
- consistency of the objectives of individual processes with customers' expectations,
- identification with the decisions taken,
- participation and involvement of the implementation personnel in the operations area of each process,
- identification of bottlenecks. elimination of duplications of effort,
- shortening and simplifying the processes occurring in the insurance company,
- optimisation of operations,
- reducing the costs of operations,
- defining the powers and responsibilities.

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THE SOCIALLY ENGAGED CORPORATION - ATTITUDES AND KNOWLEDGE RELATED TO COLLABORATION WITH NON-GOVERNMENTAL ORGANIZATIONS

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Abstract: Collaboration between business and non-governmental organizations (NGOs) is a relatively new phenomenon in the Polish market. It appears, however, that corporations recognized as socially responsible in Poland are starting to see greater benefits than before in collaboration with the third sector. More and more often, the collaboration involves an exchange of different resources and not merely sponsorship of specific events or social campaigns. The present study stresses the developmental aspect of the business–NGO collaboration. The collaboration by entities has been analyzed on the basis of recent literature dealing with sustainability management, Corporate Social Responsibility and business–NGO relations, and also on own research. The study discusses the conceptions of socially responsible corporations reaching new markets and customers on the basis of collaboration with NGOs.

Keywords: socially responsible corporation, corporate social objectives, non-governmental organizations, NGO, third sector, business sector, sustainability, NGO resources, benefits of collaboration with the third sector, Bottom of the Pyramid, social innovation, intersectoral relations, intersectoral collaboration, business–NGO alliances.

1 Introduction

“However the future unfolds, it is clear that CSOs¹ will be a significant player in the new landscape of responsible governance and accountability, as both a counterbalancing force and a partner with governments and business. In fact, I believe CSOs will be the responsive glue that holds society together in the turbulent years ahead.”²

Socially engaged corporations combine several novel conceptions of economic growth as a response to the turbulent modern reality: social innovation, sustainability, or even social economy that cures the effects of economic recession. Most corporations recognized as socially responsible in Poland take up relations with non-governmental organizations (NGOs) or non-public organizations (NPOs), whose names stress their separation from activities of the state or civil society organizations, defined as organizations grouping members of civil society. The activities of the above organizations are those of the third sector, as opposed to the market and public sectors. For description and research purposes, we assume that a socially engaged corporation is an entity that follows the Corporate Social Re-

sponsibility 2.0 (CSR 2.0³) management strategy (in W. Visser’s complex approach) or other strategies picked from the above general CSR management trend, for example: strategic philanthropy or cause-related marketing⁴.

Literature dealing with the socially engaged corporations, that is, for-profit entities that, within the pursuit of their business objectives, also attain social objectives (if to different extents and with varying intensity), very often takes up the issue of relations between the sector of such corporations and the NGO sector. The literature on cross-sector relations examines the relationship of entities that cooperate to their mutual benefit, the most recent publications draw attention to the development of the whole industry innovation based on collaboration between business and institutions representing the interests of consumers with different specific groups that are usually NGOs. These organizations represent the interests of specific groups: the disabled, senior citizens, or consumers of postcolonial countries. We assume that it is reasonable to explore cross-sector cooperation with an intent of the business to enter new markets and at the same time meet the needs of the beneficiaries of NGOs. It is a poorly

¹ CSO - Civil Society Organization

² Visser W. - *The Age of Responsibility: CSR 2.0 and the New DNA of Business*. John Wiley and Sons, Kindle Edition, p. 224.

³ Ibidem.

⁴ Kotler P. - *Corporate Social Responsibility, Doing the Most Good for Your Company and Your Cause*. Wiley, 2005.

studied area of cooperation, which can bring positive mutual results consistent with the nature and mission of partners from very different sectors. Besides, the described relations between the business and the NGO sector pertain not only to collaboration between different categories of entities, but also to their interaction even if such institutions never actually become partners. In this situation, we deal with a relation that is actually an encounter between the two sectors, neither of which is autonomous: instead, they each compare and draw inspiration from the other sectors' solutions. Whether it is corporations that draw inspiration from NGOs' solutions or vice versa is of no significance here. The common denominator that made the authors of selected studies into management of a socially responsible corporation take up the issue of intersectoral relations is management for sustainability interpreted as the corporation's ability to grow and survive in the changing and turbulent socio-economic environment. The building of a management strategy based generally on responsibility, for example, green responsibility or responsible building of relations with the corporation's stakeholders, fits in the new and intensely studied trend of sustainability – the corporation's responsible development for the benefit of its own and society's future. Authors such as Visser, Prahalad, or Austin, who propose business management models, consider the impact of relations between the for-profit and the not-for-profit sector on the corporation's ability to survive and constantly grow. It can be observed that such models are most adequate for the corporations that already collaborate with NGOs. Intersectoral collaboration seems to be the remedy for the changing and turbulent environment of corporations that may thus stand better chances to survive the series of shocks they encounter on the road to development. In the subsequent parts, the study will present the latest management concepts related to the cooperation of business and NGOs and then we will present the results of the study to verify the phenomenon of expanding the business into new markets through cross-sector cooperation. We analyze in the following parts of the article test results for the corporate and NGO resources and business advantages, the prospects for the development of cooperation to explore new markets, and present business evaluation of activities reaching out to new markets.

2 Social engagement-related management concepts: sustainability – intersectoral relations – social innovation

One of the thematic areas related to the cooperation between the business sector and NGO sector is management in socially engaged enterprises. We assume that socially engaged companies are those that implement strategies of CSR, which is sufficiently comprehensive and included in the strategic management of the company, according to the concept of CSR 2.0 by W. Visser⁵. Businesses with CSR 2.0 that cooperate with NGOs on the basis of this cooperation affect strategic management. In this section, we present briefly the three most important and the latest theoretical concepts concerning the social commitment under which the company develops strategic management.

As opposed to its predecessors focused on averaging products and services, the new management era, which A. Nicholls and A. Murdock call the social innovation era, creates business models so as to respond to consumers' needs in as detailed and individualized manner as possible. Nichols and Murdock define social innovation as a response to the negative social and ecological side effects of the preceding eras⁶. The authors of the "social innovation" term refer to the theoretical and research contribution of C.K. Prahalad, who was the first to observe that the trend shaping the new management era, the era of social innovation, is outsourcing as the common element noticeable in analyses of the business models of different corporations. Outsourcing is omnipresent and used by multiple corporations; it is, however, special in the context of the socially engaged corporations as it frequently consists of their collaboration with NGOs. Although the actual term is not used, outsourcing appears in J.E. Austin's analysis of intersectoral collaboration, where in the described cases of collaboration between socially engaged corporations and NGOs, the corporations were involved in activities that could have been outsourced: the testing of products by NGO personnel, establishing contacts with suppliers, or development of entire distribution channels. "These activities represent the fastest growing marketing expenditure category, pumping around a half billion dollars into NPO collaborators. Many of these collabo-

⁵ Visser W. - *The Age of Responsibility: CSR 2.0 and the New DNA of Business*. John Wiley and Sons, Kindle Edition, p. 36.

⁶ Nicholls A., Murdock A. - *Social Innovation: Blurring Boundaries to Reconfigure Markets*. Palgrave Macmillan, New York, 2012, p. 2.

rations are the participants' initial relationships and are not preceded by a philanthropic stage relationship."⁷

In the absence of specific relations with NGOs, such activities might also be carried out on a business-to-business basis. Own research also confirmed that some corporations outsource specific tasks to third sector entities. This is illustrated by a respondent's following statement: "We outsource it to Akademia Rozwoju Filantropii as we have corporate accounting and no experts in the settlement of donations, for which reason we receive support from our social partner: every now and then, we ask them over for a review to check and verify the accounts." Austin stresses that long-term collaboration with NGOs makes it possible to establish a relationship strong enough to be profitable to both parties. On the basis of various alliances, Austin analyzed the intersectoral relations to find that the most mature and sustainable form of collaboration between the for-profit and the not-for-profit sector is the integrative level, where the intersectoral relation is a strategic tool used to implement the corporation's key projects with the NGO – from the corporation's perspective – accomplishing that corporation's business objectives, and the corporation – from the NGO's perspective – accomplishing social objectives. At this level of collaboration, the two parties tend to strongly identify themselves with each other. Austin also distinguished two other phases: philanthropic and transactional, that may result in the corporation's reaching the integrative collaboration level. "It was recognition that cross-sector relationships come in many forms and evolve over time that led me to characterize the degree and form of interaction between nonprofits and corporations as the Collaboration Continuum."⁸ The corporation may also stop at the initial level of collaboration; however, the cases analyzed by Austin evidence the developmental nature of the business-NGO collaboration. Austin also noted the key role of the corporation's management in establishing alliances between business and social sector organizations. He stresses that the managers must be the authors, legitimizers, and motivators of the alliances. Without their initiative and en-

agement, the collaboration will never reach the integrative level⁹.

Van den Brink¹⁰ classified the stages of development of leaders and organizations, which he treated as identical. This means that the leader's development results in the organization's development. The consecutive stages of the leader's and the organization's development correspond with each other at all levels. Van den Brink observes that the supreme phases of leadership development constitute challenges for 21st century corporations. It is, however, recommended that such further phases of leadership development be pursued so as to build fully sustainable corporations. Also, the social innovation conception is based on mutual advantages; however, Nicholls and Murdock argue that social innovation is not only required in view of the profits derived by the corporation from collaboration, but may also help remedy market crisis situations.¹¹ Of the three types of social innovation, the authors define incremental innovation as the one that helps remedy a diagnosed crisis through elimination of negative side effects and institutional errors occurring in a given market. Incremental innovation focuses on product and service solutions. All examples of application of incremental innovation involve the for-profit – not-for-profit relation, where the market creates the scope for corporations or NGOs that deliver services and products to consumers who would not purchase such services and products from suppliers whose offer is targeted at developed markets. The Bottom of the Pyramid (BOP)¹² consumers only become consumers when they get an offer tailored to their needs. As shown by examples described below, relations with NGOs combined with knowledge of BOP consumers' needs are required to create a specially tailored product for the new and so far unnoticed BOP customers. The NGO Afghanistan Institute of Learning¹³ offers cheap medical services owing to professional engagement of corporations in the designing and development of such services.

⁷ Austin J.E. - *The collaboration challenge, How non profits and business succeed through strategic alliances*. Jossey-Bass, New York, 2000, p. 22.

⁸ Austin J.E. - *The collaboration challenge, How non profits and business succeed through strategic alliances*. Jossey-Bass, New York, 2000, p. 20.

⁹ Nicholls A., Murdock A. - *Social Innovation: Blurring Boundaries to Reconfigure Markets*. Palgrave Macmillan, New York, 2012, p. 60.

¹⁰ Van den Brink M. - *Individual and organizational development phases towards sustainability* [in] K. Zoeteman (ed.) – *Sustainable Development Drivers: The Role of Leadership in Government*. Business and NGO Performance, Edward Elgar, Northampton, 2012, p. 136.

¹¹ Ibidem, p. 4.

¹² Prahalad C.K. - *The Fortune at the Bottom of the Pyramid: Eradicating Poverty Through Profits*. Pearson, New York, 2009.

¹³ <http://www.afghaninstituteoflearning.org>

Another example of a specially tailored product is the medical company, Aurolab¹⁴ that evolved from a charitable NGO established in 1992 and manufacturing quality lenses priced 90% below lenses sold in developed markets. Kickstart¹⁵ is an organization that assists in the formation of new businesses that offer cheap services to BOP customers. All of the above examples resulted from relations between the for-profit and the not-for-profit sector. Involved in some cases are direct relations between specific entities from the two sectors, that are alliances of such entities, while in other cases, the intersectoral relations consist of mutual inspiration to develop business solutions.

3 Corporate and NGO resources and business advantages

Analysis of the business–NGO collaboration may hardly leave out the issue of the parties' resources, although it has to be admitted that for many years, the relations between the business and social sector entities were based on not-too-sophisticated resources. The basic trump card of business for which the NGOs strove are funds that have always posed a serious problem in the third sector. On the other hand, NGOs had little to offer to business, thus creating their image as weak entities in need of assistance and not as potential negotiation partners.

However, the mutual perception of the two sectors has been changing for the last few years: they get to know each other and start to notice the broad range of each other's resources. As follows from Polish examples of private–social partnerships and from research projects¹⁶, the collaboration between such entities may become much more effective if a number of resources is utilized that used to go unnoticed until quite recently. Beside the funds that always determined the decision on collaboration and still motivate NGOs today to initiate contacts with business, the third sector entities are now aware of corporations' other resources, such as: competence, contact network, or the natural openness

to change, and flexibility of operation¹⁷. Competencies of the business sector personnel are ever more valued by NGOs as they may simply raise the efficiency of project implementation or even NGO management. Concerned here are the typical standard skills needed to manage a corporation – definitely not the domain of third sector entities. This includes, for example, personnel, finance, and project management, or the knowledge of promotion and marketing. The business contact network is a resource that may be of great practical value for social project implementation or broader collaboration with NGOs. For NGOs, access to such network means access to further business partners, an influential group the NGO would otherwise never encounter. The ability to change, conceived as flexible involvement in new projects, is a feature that encourages NGOs to establish contacts with business – especially now that CSR is growing popular.

Also, the third sector has many resources that business failed to notice just a few years ago. They can be classified as in the case of corporations. The resource of the greatest importance in the context of collaboration with business is NGO reliability. It is mentioned by many authors who analyze relations between the private and the social sector. As follows from many research projects, Polish ones included, the social sector does enjoy big social trust; this can hardly be said of business, especially during recession. According to a 2010 diagnosis, NGOs enjoy the biggest trust in the Polish public sphere¹⁸. Further, according to the Edelman Trust Barometer 2010 report, a vast majority of respondents were more willing to trust a corporation that takes up global challenges and resolves social problems in partnership with NGOs¹⁹. Collaboration with a reliable NGO legitimizes the corporation's activities in the local community, which is tantamount to protection of its local investments. Thus a business venture implemented jointly with an NGO stands better chances of gaining the friendly attitude in the public opinion. Reconstruction of a corporation's trust and reliability

¹⁴ <http://www.aurolab.com>

¹⁵ <http://www.kickstart.org>

¹⁶ Cf. M. Karwacka - *Współpraca przedsiębiorstw z organizacjami pozarządowymi jako przejaw społecznej odpowiedzialności biznesu (Collaboration of corporations with non-governmental organizations as a manifestation of corporate social responsibility)* – quantitative research carried out from May 2011 to April 2012 for the doctor's thesis.

¹⁷ Cf. L. S. Barlie, *Alliances for Sustainable Development. Business and NGO Partnerships*. Pelgrave Macmillan, London 2010. p. 44; S. Heap, *NGO's and the private sector: Potential for Partnerships?*, Occasional Papers Series No. 27, INTRAC 1998., p. 26

¹⁸ Cf. Raport. *Zaufanie Społeczne (Social Trust. A Report)*. Centrum Badań Opinii Społecznej, Warsaw 2010, p. 9.

¹⁹ Cf. *Edelman Trust Barometer 2010 Report*. Executive Summary, p. 6, available at: http://www.lewiscommunications.com/imgs/blogentries/Edelman_Study.pdf

matters also for its perception by its staff and consumers, for the consumers' loyalty and attachment to its products, and for many other areas such as, for example, the supply chain or relations with social partners. Yet another most valuable NGO resource is competency. Many persons working for the third sector are devoted to ideas and causes in which they believe, hence their high level of competency and expertise²⁰. Hence also probably their reliability, as people see them as those who know how to resolve specific social or local problems. The knowledge of local communities is particularly important for corporations planning to invest in a new market. Identification of social needs is extremely important to prevent the situation where the corporation's activities would fail to meet social expectations whether at the local or the global level. Close collaboration with an entity that may act as a competent social advisor or an equal partner jointly implementing a project may support the corporation's aim of reaching new markets. Just like NGOs, business also may find a contact network useful. Collaboration between entities from different sectors contributes to management of each and every venture towards development. Corporations usually operate within a relatively closed circle of entities that is limited to suppliers, business partners, competitors, etc. What makes such contacts and information so attractive is mainly their utter dissimilarity from the business standards and potential of serving as the basis for competitive advantage. It should also be mentioned at this point NGOs' connections with the government and international institutions, for example, those dealing with environmental or medical issues or human rights. As representatives of the third sector, NGOs are usually invited to participate in various social consultations and carefully heard, which may involve a specific opportunity for their collaborating corporations to influence the shape of the law. Powerful social impact is a resource that may be an advantage – as the ability to win over advocates for a project – as well as a drawback if the corporation's opponents are organized.

Business collaboration with any entity involves expectations as to specific profits. Recruited are usually qualified persons likely to yield profit for the corporation; entities that guarantee quality and appropriate pricing are selected as suppliers. Also, when deciding to estab-

lish collaboration with NGOs, corporations focused on the social responsibility strategy tend more and more often to be guided by the criteria of specific benefits. According to S. Waddell, "In this era of globalization and the increasingly large scale of corporate operations, this strategy holds particular attraction for medium-sized businesses that cannot easily compete in the arenas of price and service/product range. For these businesses, the long-term and local focus of NGOs can make them particularly valuable partners to develop competitive advantages."²¹

Depending on the type of cooperation, the benefits may be one-dimensional or complex and multi-dimensional in nature. The potential benefits to be derived by business from the collaboration that are mentioned most often in literature include²²:

- The benefit derived from a variety of ventures

The benefit derived from a variety of ventures undertaken jointly with NGOs that is mentioned most often is strengthening of the corporation's social image. This factor is material and self-evident to the extent that not only corporations themselves admit it but also the other stakeholders, NGOs included, are aware of the benefit.

- Risk management

The benefit seems obvious in light of the various assaults on corporations, especially the global ones. Thus collaboration with NGOs may provide the corporation, on the one hand, with the feeling of being in control, and on the other hand – with access to valuable information about, for example, public feelings to which its activities or products can be adjusted so as to avoid being boycotted by consumers or NGOs. The risk management-related benefits also apply to the supply chain organization. In view of the fact that in the case of the supply chain, a corporation is liable for its own and third parties' (subcontractors') actions or for dangerous products, its relation with NGOs that control the subcontractors may save it from a scandal or ill-repute. J. Austin stresses that one of the main benefits derived

²¹ Waddell S. - *Complementary resources. The win-win Rationale for Partnership with NGOs*,... op.cit. p. 203.

²² Austin J.E., Reficco E. - *Motivation and the Cross-Sector Alliance*... op. cit.; S. Waddell, *Complementary resources. The win-win rationale for partnership with NGOs* [in] *Terms for Endearment. Business, NGOs and Sustainable Development*, ed. J. Bendell, Greenleaf Publishing, 2000, p. 197; Prahalad C. K., Hammond A. - *Jak obsługiwać biednych i dobrze na tym zarabiać? (How to serve the poor and make a good profit)*... op. cit., p. 18.

²² Yaziji M., Doh J. - *Organizacje pozarządowe a korporacje (NGOs and Corporations)*, ... op. cit., p. 192.

²⁰ Yaziji M., Doh J. - *Organizacje pozarządowe a korporacje (NGOs and Corporations)*. Wyd. Naukowe PWN, Warsaw, 2011. p. 187.

from risk management is the possibility of maintaining the *status quo* that is advantageous to the corporation.

- Cost reduction that may result from several reasons One of them is development, in collaboration with a competent NGO, of improvements of, for example, the production process, or modification of work places (office premises) towards greater environment-friendliness, which lowers the entire corporation's costs in a longer perspective. Cost reduction is also most important when designing and implementing social projects, to which NGO experts contribute their knowledge, experience, the distribution or communication channels as well as volunteers whose work and commitment assist the implementation of even the most complex ventures.

- Design and development of new products

Ever more corporations all over the world come to understand that collaboration with third sector entities may lead to many successes in the research and product development area. The NGO experts' professional knowledge is useful not only for identification of social needs but also for confrontation of the "business" with the "non-business" approach to a specific problem, and may yield innovative solutions – both well-prepared from the market perspective (the corporation's responsibility for i.e. promotion) and carrying considerable social value (the NGO's responsibility for i.e. product safety).

- Entering new markets

Many NGOs are, by their very nature, linked to marginal communities and markets that might seem unattractive for business. However, as many corporations had the opportunity to learn, such seemingly unprofitable markets may well offer an opportunity for the corporation's growth. The attractiveness of such markets was noticed by the abovementioned author of the BOP conception, Prahalad. Many corporations have already entered such markets and scored big success there. Corporations established there offer a variety of services to the local population, such as IT education, language learning, and specialized vocational training. Financial sector corporations (as e.g. Citibank) followed the idea of the Nobel Prize winner Muhammad Yunus – the author of microfinance solutions – and also started to offer loans and financial services in BOP markets²³. Exploring new markets, the corporation may

also use an NGO's distribution channels and communication systems.

- Personnel development

The employees of corporations collaborating with NGOs often discover new areas of interest, and also – importantly from the business (and, especially the socially responsible business) perspective – learn the "community spirit" language and come to understand the reasons of various social problems, which eventually makes it easier for them to reach and communicate with social groups of interest.

- Gaining new and socially sensitive consumers

The fact of collaboration with a NGO tends to persuade consumers to stay loyal to such socially and/or environmentally engaged manufacturer. This is often done through so-called cause-related marketing (CRM), where upon selling its products and/or services, the corporation declares that a specific portion of its profit will be donated to a specific social purpose.

- Implementation of change and creative support

The authors of all seminar and conference pronouncements as well as publications stress the importance of innovation for competitive advantage. Many global corporations now understand that quite a lot of innovative solutions may result from collaboration with third sector entities. The social organizations' financial problems often force them to creatively utilize their resources and to apply non-standard thinking to overcome a variety of obstacles. Besides, as has been mentioned above, the complementary business and NGO resources may be combined in a most creative manner.

4 Business–NGO collaboration as appraised by observers and the possibility of discovering new markets – study findings

Due to the international nature of CSR as a business activity, we interviewed²⁴ market CSR managers and observers and at the same time leaders of change in the area of social responsibility of business in Poland. A study was carried out on the basis of the above new publications on economic development of the

²³ Ibidem, p. 8.

²⁴ Own qualitative study. A subgroup of 3 respondents selected from among the 12 managers covered by the study: observers of CSR-related trends, personnel of advisory firms and an NGO grouping socially engaged corporations.

business sector that collaborates with NGOs²⁵. The purpose of the study was to learn the opinions of observers and CSR managers on the role of collaboration with NGOs in the reaching of new markets and new customers. It was also to find out to what extent their opinions demonstrate the corporations' readiness and willingness to reach such new customers or markets. Do the CSR managers observe changes in business management within already implemented social engagement? Based on information and experience acquired in collaboration with non-profit organizations, do they contribute to attainment by the corporation of business objectives other than the gaining of new customers?

A belief prevails among the observers that collaboration with NGOs may offer a great potential for corporations forced to seek new approaches to their existing and prospective customers. With the huge number of similarly priced products and services of similar quality, the methods of gaining new customers that have been used so far are no longer effective. To quote a respondent, "business is starting to understand that the existing channels of communication with the target groups cease to work". Today, however, apart from the relatively few cases (compared to the number of corporations in Poland), the business-NGO collaboration in the area of discovering new markets is developing less dynamically than in the West. This is sure to result from the very low levels of social capital – a specific foundation of any collaborative relations. According to observers, the developments in the Polish market consist in a noticeable and growing (even if still slight) nationwide percentage of successful and innovative examples of collaboration that are deserving of imitation. It seems that industry is the key element in analysis of private and social partnerships: not all corporations realize the need for collaboration with NGOs, whether solely for reputation purposes or to reach new markets. This results largely from the profile of stakeholders with which the corporations have crucial relationships.

²⁵ The study was carried out from November to December 2013, and consisted in individual medium-standardized interviews with 12 managers working solely in the Corporate Social Responsibility (CSR) area and other managers of a similar level performing other tasks as well, not only those from the CSR area. The sample included nine CSR managers, two advisers from consulting firms, and one business consultant from an NGO grouping socially responsible corporations.

Although they notice the big business development potential, the market observers exercise prudence when projecting fast qualitative and quantitative changes in the area of intersectoral partnerships and new markets being discovered by business owing to such alliances. According to them, a number of obstacles hinder or even hamper lasting collaboration between corporations and NGOs that would help reach new customers. For this situation to occur, it seems that both parties must be willing to learn from each other and to be open to each other's needs and objectives.

Alas! the main obstacle is the low level of social capital, which in turn generates further obstacles. According to the observers, the most noticeable obstacles include superficial nature of contacts between entities; poor research into each other's sectors; narrow conception of potential collaboration; lack of leaders with a vision; instrumental approach to collaboration; lack of promotion of the good practices; and mental obstacles. To the observers, the superficial nature of relations is reflected in the absence of any need not only to make such relations deeper but even to engage resources other than usually in the process of collaboration. NGOs hope mainly for financial support, while business – for its part – seems incapable of offering anything else. Due to such superficial approach towards the partner, the relation is likely to be short-lived, as there is no room for any serious reflection about innovative projects that might arise from engagement of the parties' different resources. According to the observers, what still prevails in Poland is quick and instrumental utilization of the partner within planned collaboration, usually for image-boosting purposes. There are but few examples of successful collaboration carried out by market leaders and treated by most as the basis for own activities. In the observers' opinion, most Polish corporations treat intersectoral collaboration as a trend that they imitate without any deeper analysis and adjustment to their own needs. The key to reach new clients and markets is to build long-term collaboration and relations based on mutual trust and loyalty; however, to quote our respondents, "there's but little long-term thinking here".

The short-sightedness can also be considered from another perspective, that is too strong a focus on one's own closest environment, needs, and organization, as well as perception of the reality from the viewpoint of one's own sector only. The observers stress that many third sector entities, while treating social activi-

ties as justified and necessary, lack flexibility that is required to develop a joint standpoint with business, which results in the situation where “the organizations are still mainly after money”. On the other hand, managers manifest a much similar attitude, perceiving the market and potential partners in the limited context of short-term business objectives. Many a time, this attitude results in a lack of elementary knowledge about the third sector, of understanding of the possible links between the two sectors, and of the need to seek innovative social solutions. In the experts’ opinion, a serious problem that obstructs the road to intersectoral collaboration is the shortage of leaders. The experts agree that only managers with a vision and a broader view of the reality, going beyond their own industry and sector, would be capable of transforming the current state of affairs into a space where entities from the two sectors might establish links with each other, by means of identifying the methods of establishing such links, implementing joint projects, and contributing to such projects with engagement. It is leadership that the observers see as the remedy and means of actually changing the situation: “if leadership based on values emerges, both within NGOs and business, this will create a plane of shared values for such people to meet easily, we still suffer from a shortage of good leaders. I would like to stress the word “good” as what I mean here are deeply rooted values, methods of operation, charisma, the ability to generate social capital and responsibility for such capital.”

At the same time, lack of leadership means that the need to bring the two sectors closer to each other is not developed, and efficient initiators of such change on the national scale are lacking. Although there are already some corporations in the market that treat CSR very seriously and strategically, in a vast majority of cases, we still cope with the situation where top managements see CSR-related issues as a mere trend worth imitating and not as a result of local needs aimed at collaboration towards actual benefits.

5 Collaboration with NGOs and reaching new customers from the perspective of socially responsible corporations – study findings

The managers confirmed that pursuing social objectives within their CSR strategy, corporations also attain

a variety of business objectives, and therefore, derive from their alliances with NGOs, the experience and knowledge that can be used to implement product innovations, develop new products, or develop such products and services for new customers.

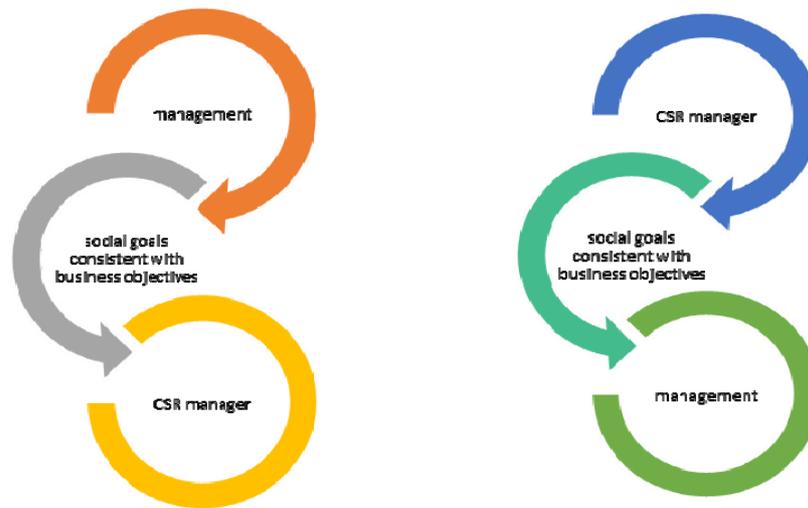
A prevalent majority of the interviewed managers noticed the impact of intersectoral collaboration on attainment of the corporation’s business objectives; however, a few corporations only actually introduced product changes or reached new customers owing to their collaboration with NGOs. All examined corporations were aware of the possibility of attaining business objectives related to image and reputation through collaboration with NGOs. As appraised by the CSR managers, consistency of the activity profile of the organization with which the corporation collaborates with its social objectives is of material importance for business activities.

As follows from analysis of the managers’ responses, corporations are guided by various reasons when setting the corporate social objectives. In some cases, corporations are guided solely by the social interest while in some other ones, they are guided by consistency of the organization’s social objectives with the corporation’s business objectives. All examined corporations collaborate with NGOs that reach people in need and at the same time, the specific corporation’s potential customers. The sample included corporations where:

- the pursued social objectives followed from the nature of the corporation’s business activities and were initiated by the management as an element of that corporation’s strategy,
- the pursued social objectives were related to the nature of the corporation’s business activities, and resulted from previously established corporation – non-profit relations based on charitable support; information about the possibility of attainment of business objectives as well was provided to the management by the manager.

On the basis of the study, two types of relations based on combination of the business with the social objectives within a corporation can be distinguished. One of the types follows from strategic management, while the other one influences strategic management.

Types of corporation – non-profit relations based on combination of the business and the social objectives (see Fig. 1).



Type 1. Result of strategic management

Type 2. Impact on strategic management

Figure 1. Own analysis

As appraised by the managers, the higher the consistency, the longer the collaboration aimed at pursuing social objectives together with the non-profit partner. The managers frequently mention the corporations' aim towards long-term relations within joint implementation of projects with a non-governmental partner. The managers use such terms as:

- stages of collaboration: social dialog, formulation of the needs of new consumers – the organization's beneficiaries, research into new services or products carried out by the organization; this is manifested, for example, by the following response: "It is not that we prepare and test products: we first inquire what is needed, then develop a specific conception and product and come back with it; however, we are now working towards their participation in the entire process. Such are our intentions: we are now into dialog focused on digital integration and also into projects for senior citizens."
- many years of collaboration giving professional nature to the business – non-profit relation: "Following two pilot projects, we asked the Academy to join in, developed the method together with them, invited entries for a competition, prepared a handbook – and within several years, they became our professional partner."
- mutual gaining of knowledge and experience, as described in a selected response: "Let me tell you

the truth: we always say that we would never strike upon the great ideas they have; this is extremely inspiring. This is why I am always embarrassed when our colleagues – friends, actually, after so many years of collaboration – say that they have learned so much from us: like I said, this works the other way as well. For example, when developing new programs or projects internally, I largely base on the experience and knowledge obtained from them."

- assumptions as to long-term social activity without projecting the measurable effects of collaboration, absence of so-called quick-wins, lasting collaboration despite initial problems with implementation of a social project: "This is a specific long-term partnership, and what I mean is not the one and not ten years' perspective I mentioned when talking about a specific project or projects: here, I do mean such many years' collaboration. Thus I believe that such genuine partnership with NGOs is only possible in the case of corporations that follow a specific global policy, a global approach, and develop some projects globally too."

At the same time, the managers appraise long-term collaboration as:

- yielding new solutions,
- crucial in terms of impact on brand association with a specific social activity,

- offering the possibility to acquire crucial expertise in an important area related to a specific product or service,
- involving the corporate management's big investment in innovation consisting in a quest for new "green" production processes, new manufacturers, products, and customers.

As an interesting conclusion from the study is that three types of customers can be distinguished who are reached by the corporation, whether with or without intent. It turns out that collaboration with NGOs may, first, provide the corporation with access to new customers – the social partner's direct beneficiaries (and their families); second, shape the future market; and third, help establish relations with customers being in fact the corporation's business partners. The first case involves corporations that are aware of the need to target so far marginal social groups and thus to modify their products. This happens, for example, in the settings of collaboration with organizations for people with disabilities, the sick, or the elderly. The respondents admit that market and demographic changes make them seek new market possibilities; they openly state that: "for many years, the elderly were seen as being outside a specific mainstream in all marketing surveys, target groups, target sales, etc.; today, instead, in view of the fact that society is growing old, we treat them as a new market offering new opportunities."

Other, this time prospective customers that are reached by corporations are children. This group is difficult to define explicitly in the future market category, as corporations that become involved in collaboration with NGOs supporting children seldom have projections calculated as precisely as in the former case. However, engaging their resources in projects in support of the children, the managers also consider the possibility of shaping a future consumer market. To quote a female respondent, "[if] we deal with very big projects involving millions PLN, the objectives tend to be more ambitious so to say; take a project aimed at social development of a community, involving children from small rural communities – the assumption is that if such persons go to school or receive student support, our vision is that one day they will be building consumer society as in fact our future employees or customers."

It turns out that the third group of clients that can be accessed easier through collaboration with NGOs are business partners. It turns out that an NGO grouping

various business people facilitates their direct contact with one another. Meetings and relations established in the settings of joint work for a social project is definitely conducive to development of relations and to future continuation of strictly business talks. As a female respondent stresses, "The Association invited many top corporations to join the project; such corporations are our potential partners, as we have reached them in entirely different conditions, and it is much easier to talk to people you have met in settings such as collaboration within a social project instead of just visiting their office with an offer what I mean is that feeling of community, knowing that we have more in common, an objective other than just meeting the sales targets."

While in the former two cases, the reaching of customers is first and foremost to build and maintain the corporation's image, reputation and trust, which may lead to relations being established with potential clients, what is crucial in the latter case are relations between the corporation and its potential customer (business partner), and its reputation is of secondary importance.

Therefore, it can be concluded from the study that the CSR managers, the corporation representatives collaborating with NGOs, have knowledge about the possibilities of such collaboration. The biggest group among our respondents was persons who had been collaborating with NGOs for several years and with time, become more and more aware of the possible impact of such collaboration on the corporation's product and services change. Many managers also declared the intention to maintain the alliances to attain further business objectives likely to rank as strategic: brand recognition as responsible or influencing public decision makers regulating the specific industry. Collaboration developed at corporations whose management was interested in it and either inspired such collaboration or responded to information coming from the ranks. This confirms the observations made by Van den Brink and Austin, who associate the development of a corporation's relations with engagement of its leader. Also, our respondents stressed the leader engagement factor: "for the CSR strategy to become a genuine and actual element of the financial strategy, which is the best solution for the organization, it must be properly positioned among management's priorities. The example comes from the top: therefore, those at the top have to understand this business approach before it can actually happen." The CSR managers' high awareness and open attitudes are manifested in their statements, where

the non-governmental partners are described as experts in the corporation's area of interest, supervisors and advisors in specific management processes. The managers declare that they carry out detailed selection of non-governmental partners from the viewpoint of their scope of activity or specialty, professionalism and transparency, and to a slight extent of their revenues and media-friendliness, which also demonstrates the experience of such managers in and methodology of collaboration with NGOs. Polish chances for intersectoral collaboration – conclusions from the study.

6 Recapitulation

All of the studied corporations with extended CSR strategy and many years' experience of collaboration with the non-governmental sector were international businesses, which confirm the frequent trend of introducing an example of social innovation into the international corporate policy. Even in situations where company managements utilized the experience of CSR managers, the corporate social engagement was usually initiated by the corporation's headquarters located outside Poland.

In the opinion of observers who have knowledge about the progress of such issues in developed countries, what Poland needs first and foremost are leaders with a vision. Polish society needs leaders capable of noticing the unusual potential of intersectoral collaboration. Besides, which is also strongly related to the shortage of valuable leaders, the language of the social debate on difficult issues should be changed, and hostile participants in such debates should be replaced with persons who understand the value of collaboration and joint problem-solving. One of the respondents stressed the issue he saw as important: the educational system that develops competitive instead of collaborative attitudes and promotes individuality instead of joint activity. In our opinion, the aforementioned needs would be extremely difficult to satisfy in a short time. Nevertheless, we believe that good habits and attitudes can be shaped anyway through promotion of good practices.

The interviews with CSR managers show the actual division into those who treat collaboration with NGOs as a means of business development in areas such as image and reputation only, and others who perceive the potential of such collaboration and pursue specific business objectives, the reaching of new customers in-

cluded. The managers were sampled from a group of about 150 socially engaged corporations in Poland, mostly international. In turn, such corporations are about one-fifth of all international corporations with representations in Poland. Therefore, the number of socially engaged corporations is rather small compared to all corporations operating in Poland, of which there are about 500. Thus our findings cannot possibly be generalized; nevertheless, we wish to stress that our purpose was to initially identify issues related to the reaching of new markets through collaboration with NGOs. It might be said that there are examples of reaching new customers through collaboration with the NGO sector; however, we treat such examples as precursory. Prompt implementation of collaboration with NGOs as a method of boosting the corporation's image taken into account, we consider it possible that private-social partnerships will be developed for the purpose of reaching new markets and customers and modifying the corporation's products and services. In our view, this direction of the corporation's development has a future; we share Austin's opinion that collaboration consisting of attainment by the parties of particular objectives may serve as an introduction to collaboration for shared objectives. Examples of such shared objectives of entities from different sectors may include: development of a product to support persons excluded from the market or sick, but provided by the corporation to such persons in the market and not philanthropic terms. Collaboration with NGOs and the resulting innovations in business thinking is a very fresh concept, which, we hope, will be discussed within intersectoral collaboration. Nevertheless, it seems consistent with the assumptions of sustainability, a trend that considers the persistence of business and sees the chances for its survival in its opening to new stakeholders and then to the offer of attaining shared objectives in partnership with such stakeholders. What we see as the premises for treating the business-NGO collaboration as a factor of strategic changes in socially responsible corporations are, first, the managers' perception of the impact of many years' collaboration, and second, the two types of collaboration related to attainment of some strategic objectives, as distinguished on the basis of the study. This is consistent with Austin's assumption that collaboration between non-governmental and business entities is a specific continuum intended to result in the partners' pursuit of shared objectives. Therefore, we point to the non-governmental partners' important resources

and the benefits that are mentioned today become crucial in the prospective thinking about corporations' survival in a turbulent environment.

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DATA MINING AND STATISTICS METHODS FOR ADVANCED TRAINING COURSE QUALITY MEASUREMENT: CASE STUDY

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Abstract: Advanced training courses in the energetics field is a very important part of human reliability growth. In the words of S.E. Magid, chief of Technical Educational systems in Energy Technologies, UNESCO department: "The number of forced outages due to failures of equipment on the power stations -30 %. The share of operational personnel fault in these infringements makes considerable size (to 15%). As a whole in the Russian Open Society 'United Power Systems' the infringements percentage because of the personnel from infringements total makes 2%. At the same time, on power stations this quantity makes 18%. In power supply systems of Siberia the relative quantity of infringements because of the personnel reaches 50%." [1].

Keywords: advanced training course, educational data mining, statistics methods.

1 Data and methods

In this case, the HR department must receive students' response and adequately analyze it. For this purpose, the HR department of one of the largest power providers prepared a questionnaire for students (electrician, electric engineers) who have a course under a specially organized Advanced Training Courses department. In the questionnaire, students marked some parameters of courses, which were re-coded for analysis purposes (Table 1). Every parameter was marked in the diapason from 1 (bad) to 10 (excellent). Questionnaires were deanonymized (we did not have access to the questionnaire preparation process, so we cannot adequately explain this fact).

It should be noted that the last parameter "General impressions about provided training" in fact is generalizing for all others (a target variable), that is, in Educational Data Mining (EDM) terminology – label.

The main goals of analysis were formulated by the HR department as:

- to estimate course quality,
- to identify the major factors influencing an assessment of a course by students,

- to make recommendations about improvement of course characteristics, the questionnaire improvements.

For the analysis we received 316 questionnaires completed by students at the end of the advanced training course. Initially data underwent cleaning for incomplete cases, because the applied methods could not process them. As a result, the dataset decreased to 301 records.

We carried out processing only in open source software: statistical programming language R [2] and data mining platform of KNIME [3].

2 Data analysis and results

Verification of normality in all fields across the dataset by the Shapiro–Wilk test gives a negative result at the 0.05 p-level. The peak is detected at level 10 (excellent) for all fields. So, for an indicator "General impressions about provided training," the histogram shows value 10 prevailing, and the values lower than 6 frequencies (see Fig. 1) are very rare, and that is characteristic for all other fields.

Table 1. Parameters and their coding for the processing

Parameter	Coding
General organization of training process	obshorg
Equipment of educational audience	oboryd
Compliance time of courses with syllabus	cootvraspis
Compliance of the course content with the declared program	sootvprogr
Practical usefulness of the carried-out training	polezn
Comprehension of a course material	dostypmat
Use of modern methods in a process	sovrmetod
Individual approach to the student	indpodxod
Efficiency of interaction of the teacher with audience	vzaimodayd
Receiving feedback from teachers	obrcvyazprepod
Receiving feedback from employees of chair	obrcvyazkaf
Interaction of students among themselves	vzaimodslsh
Existence, quality, usefulness of printing materials	razdatmat
Quality of food in the dining room	pitanie
General impressions about provided training	obsh

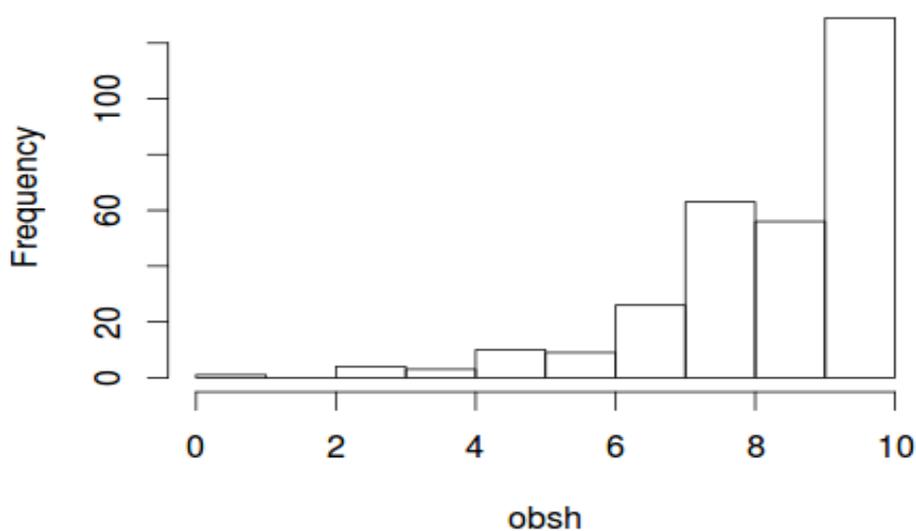


Figure 1. The histogram of the field "General impressions about provided training"

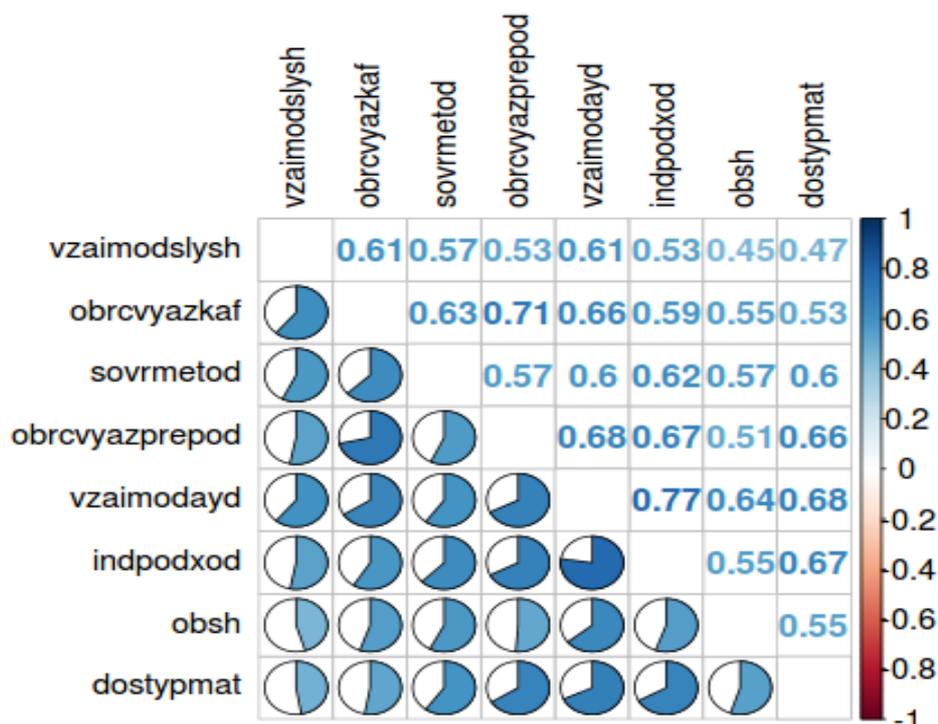


Figure 2. Correlation matrix

So, we can use only non-parametric statistics methods.

The data is ordinal, so we used Spearman correlations subsequently subjected to a filtration at the level of 0.6 with corplot package [4] of the R language (see Fig. 2).

All correlation coefficients are significant at the 0.05 p-level.

From the results it is possible to claim that there is a high level of correlation between factors "An individual approach to the student" and "Efficiency of interaction of the teacher with audience," and "Receiving feedback from teachers" and "Receiving feedback from employees of chair." Thus, it is possible to say with confidence that students practically do not distinguish between an individual approach and efficiency of the teacher, and marks feedback from teacher and feedback from chair concordantly. It is really interesting that "Individual approach to the student" and "Comprehension of a course material" are highly correlated.

It should be noted a large share of correlations in the dataset with values that can be treated as "average" (values from 0.5 to 0.7).

In the scoring process can be the groups of persons formed, operating in a similar way; therefore obtaining

information on the existence or absence of such groups was the following issue, which was resolved within an objective.

The procedure of the cluster analysis was applied for these purposes to the dataset with fuzzy C-means with the predetermined quantity of clusters equal to 4. Four groups, one of which came to about 40%, were as a result received, and other groups comprised 17% to 20% of the power of the initial dataset (Table 2).

For distinction analysis among the received clusters, medians and interquartile range (IQR) on all indicators (Table 3) were calculated.

Table 2. Respondents' answer distribution by clusters

Cluster	Elements	Percent
1	58	19%
2	117	39%
3	75	25%
4	51	17%
Total	301	100%

Table 3. IQR and medians for all parameters by clusters

Parameter/cluster	IQR, by clusters				Median, by clusters			
	1	2	3	4	1	2	3	4
General organization of training process	1.0	0.0	2.0	1.0	7.5	10.0	9.0	8.0
Equipment of educational audience	3.0	1.0	3.5	2.0	7.0	10.0	8.0	8.0
Compliance time of courses with syllabus	2.0	0.0	0.5	1.0	9.0	10.0	10.0	10.0
Compliance of the course content with the declared program	1.0	0.0	1.0	2.0	8.0	10.0	10.0	9.0
Practical usefulness of the carried-out training	3.0	0.0	2.5	2.0	7.0	10.0	8.0	8.0
Comprehension of a course material	1.0	0.0	1.0	1.0	8.0	10.0	10.0	8.0
Use of modern methods in a process	1.8	0.0	1.0	1.0	7.0	10.0	10.0	8.0
Individual approach to the student	2.0	0.0	1.0	2.0	7.0	10.0	10.0	8.0
Efficiency of interaction of the teacher with audience	1.0	0.0	1.0	1.0	8.0	10.0	10.0	9.0
Receiving feedback from teachers	1.0	0.0	0.0	2.0	8.0	10.0	10.0	9.0
Receiving feedback from employees of chair	2.0	0.0	0.0	2.0	7.0	10.0	10.0	9.0
Interaction of students among themselves	1.0	0.0	0.0	2.0	8.0	10.0	10.0	9.0
Existence, quality, usefulness of printing materials	3.0	0.0	3.0	2.0	6.5	10.0	8.0	8.0
Quality of food in the dining room	2.8	1.0	2.5	4.0	7.0	10.0	9.0	8.0
General impressions about provided training	2.0	0.0	2.0	1.5	7.0	10.0	9.0	8.0

As a whole, it should be noted high marks for all parameters by students of clusters 2–4. In fact, we must remember that questionnaires were deanonymized, so it make sense in this case and we can expect, that marks will be higher than in anonymized questionnaires.

Here we can draw some conclusions that the available information allows us to make.

The cluster 2 students mark 13 parameters as “excellent” and “Equipment and the equipment of educational audience” and “Quality of food in the dining room” in most cases on 9–10 points. Most likely, this group of students approached formally the questionnaire filling process and has to be excluded from further analysis. We think that, this cluster was formed by “panic students” who did not add the real marks in the questionnaire with their names at the top.

Cluster 1 consists of most judicial students. Especially, it should be noted a low mark in the “Existence, quality,

usefulness of printing materials” parameter in this group. In general, with respect to printing materials, distinctions between groups on this factor are significant at the 0.05 p-level (Kruskal–Wallis chi-squared = 20.5337, $df = 2$, $p = 3.477e-05$). More clearly it can be shown on a boxplot (see Fig. 3).

A similar pattern is observed for the “Quality of food in the dining room” parameter. Distinctions between groups on this factor are significant at the level of 0.05 (Kruskal–Wallis chi-squared = 20.0733, $df = 2$, $p = 4.377e-05$); thus in cluster 4, IQR is very large, the first quartile is equal to 5 points (see Fig. 4).

Distinctions on a parameter “Practical usefulness of the carried-out training” are also statistically significant at the level of 0.05 (Kruskal–Wallis chi-squared = 38.5622, $df = 2$, $p = 4.23e-09$); thus 25% of the first group marked usefulness lower than 5 (see Fig. 5).

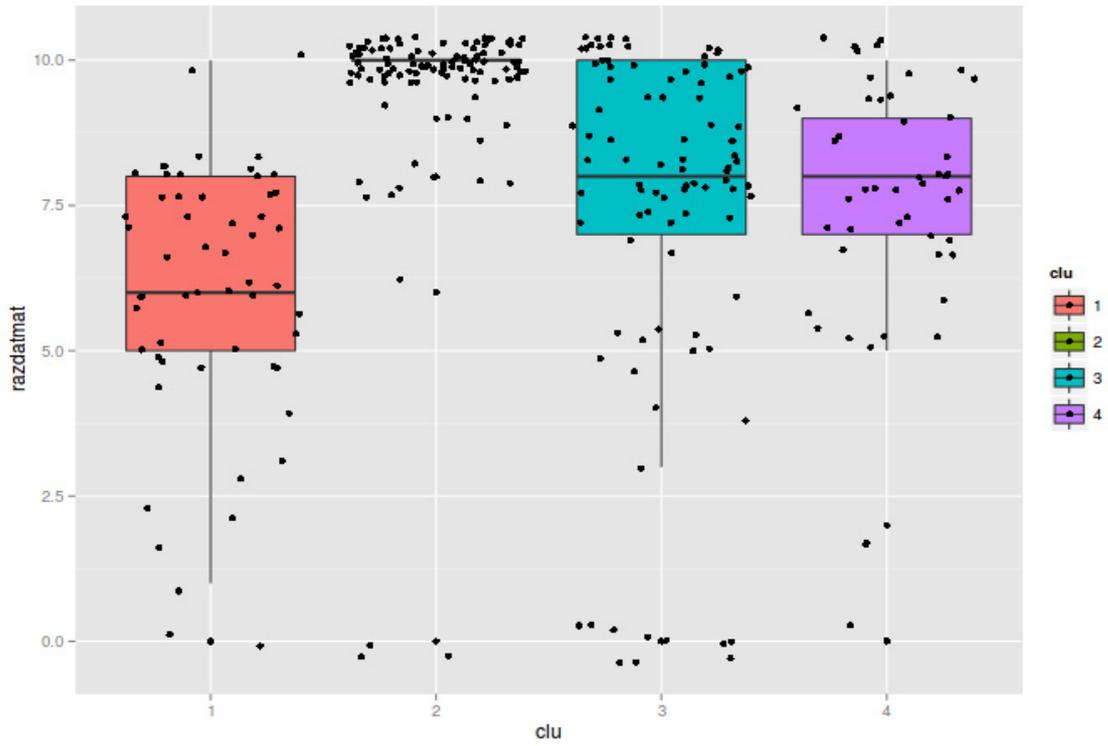


Figure 3. Printing material scoring in clusters 1–4

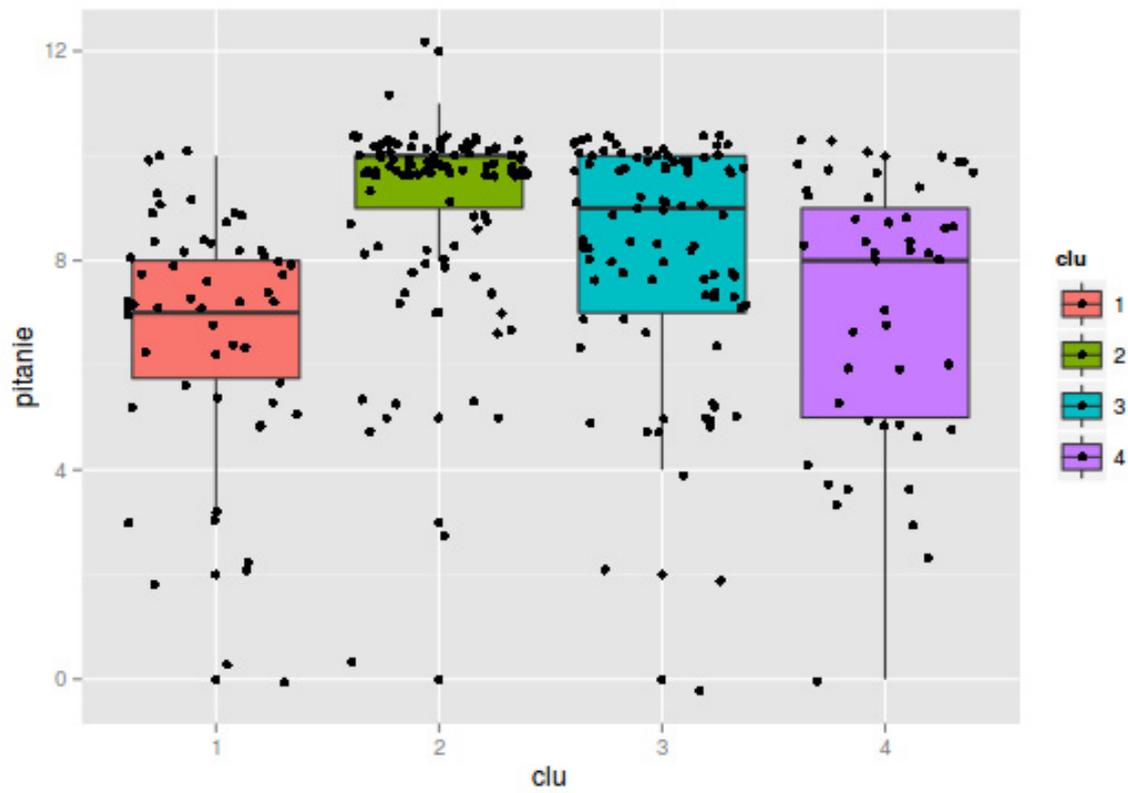


Figure 4. Marks for "Quality of food in the dining room" in various groups

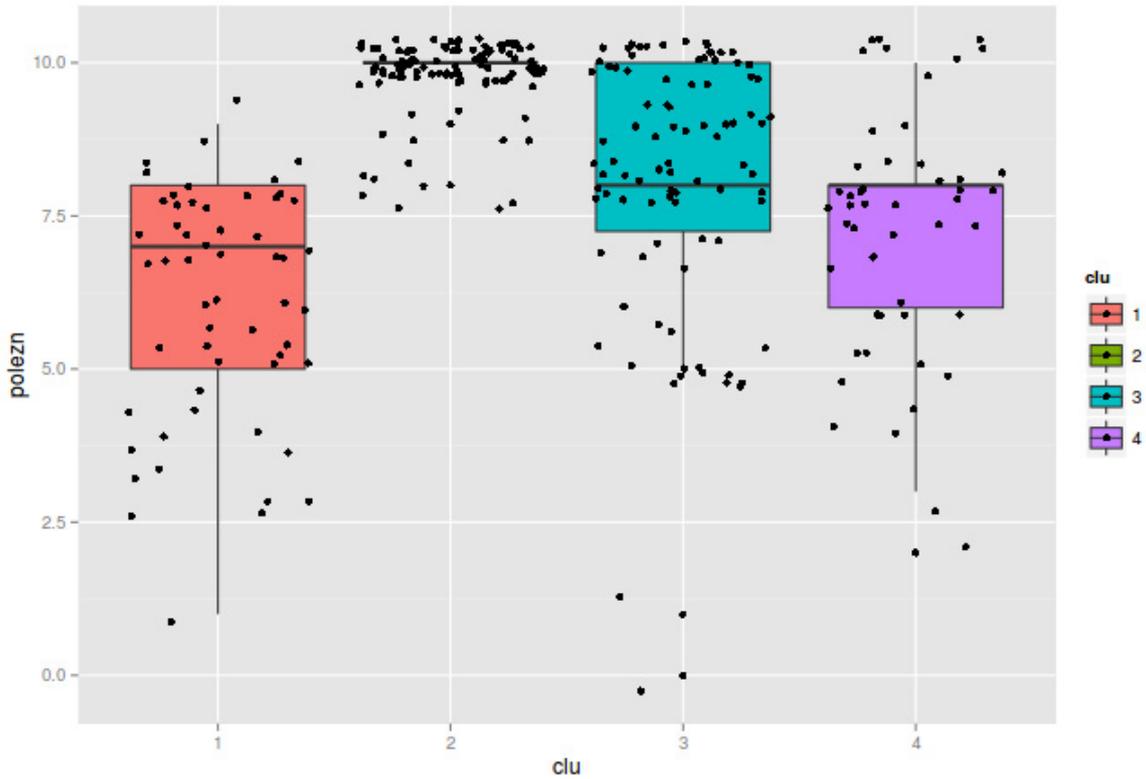


Figure 5. Marks for "Practical usefulness of the carried-out training" in various groups

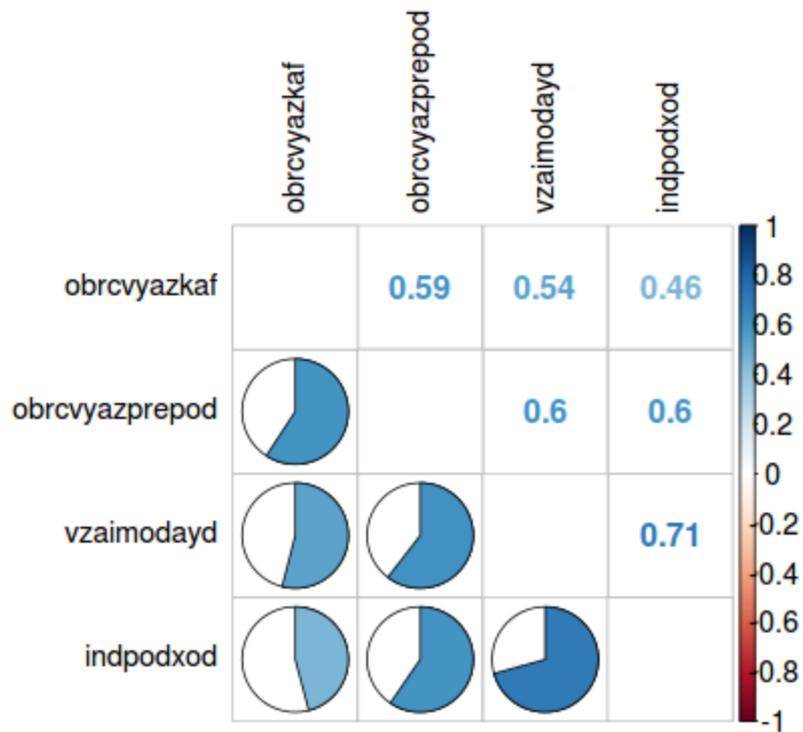


Figure 6. Correlation matrix with 0.6 threshold after a filtration of cluster 2

Table 4. Factor loadings (in variation explained order)

Parameters	MR1 (Factor 1)	MR2 (Factor 2)	MR4 (Factor 4)	MR3 (Factor 3)	MR5 (Factor 5)
General organization of training process	-0.003	0.717	0.289	0.228	0.026
Equipment of educational audience	0.137	0.501	-0.028	0.002	0.021
Compliance time of courses with syllabus	0.001	0.416	0.175	0.035	0.358
Compliance of the course content with the declared program	0.332	0.131	0.554	-0.011	0.327
Practical usefulness of the carried-out training	0.228	0.135	0.468	0.050	0.066
Comprehension of a course material	0.571	0.135	0.501	-0.009	-0.048
Use of modern methods in a process	0.203	0.693	0.274	-0.135	-0.063
Individual approach to the student	0.786	0.187	0.143	-0.066	-0.029
Efficiency of interaction of the teacher with audience	0.761	0.169	0.166	0.147	0.241
Receiving feedback from teachers	0.654	0.192	0.361	0.147	0.136
Receiving feedback from employees of chair	0.254	0.596	0.063	0.194	0.273
Interaction of students among themselves	0.186	0.547	0.042	-0.009	0.301
Existence, quality, usefulness of printing materials	0.068	0.079	0.074	-0.221	0.326
Quality of food in a dining room	0.101	0.109	0.059	0.716	-0.096

A similar pattern is observed for "Equipment of educational audience," "Comprehension of a course material," and "Individual approach to the student" parameters.

About a third of respondents are in clusters 1 and 4, in which lower marks than those described above are observed for most of the parameters.

For identification of the hidden factors and their relative importance, the factor analysis was used. Previously cluster 2 was excluded from analysis, as mentioned before.

The filtration led to the loss of a significant part of linear correlations (see Fig. 6).

The analysis of statistically significant parameters leads to the conclusion that students closely coordinate "An individual approach to the student," "Efficiency

of interaction of the teacher with audience," and "Receiving feedback from teachers" (correlation coefficient not less than 0.6). The average level of communication (0.59) between factors "Receiving feedback from teachers" and "Receiving feedback from employees of chair" remains.

Results of the factor analysis (psych package [5]) allow us to assume the existence of five hidden factors (Maximum Likelihood $\chi^2 = 39.804$, $p < 0.134$) (see Table 4).

These five factors explain about 50% of a dataset variation; thus factors 1 and 2 explain 16% of a variation, and factors 4, 3 and 5 explain about 8%, 5%, and 4% of variation respectively.

The graphic interpretation of results (see Fig. 7) gives more clearly the structure factor composition.

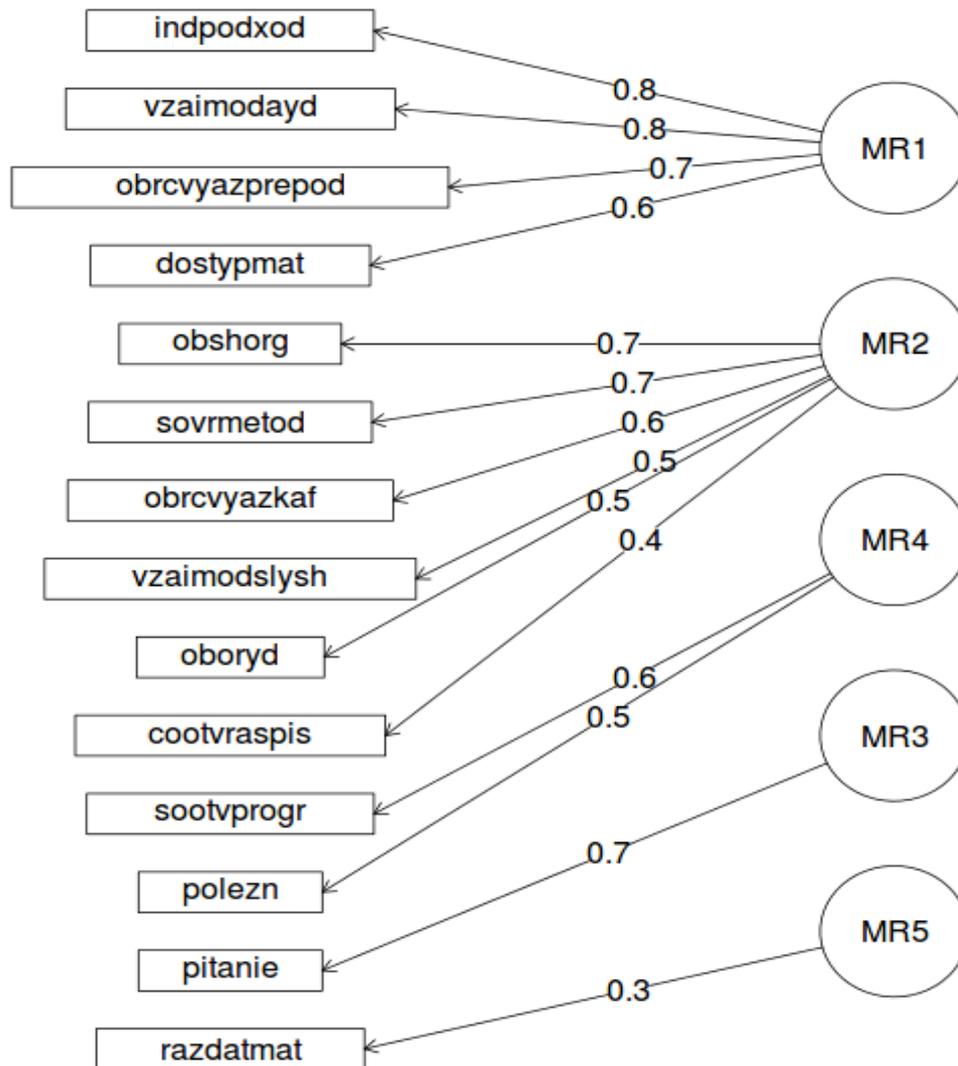


Figure 7. Factor structure

The first factor can be treated as "Individual skill of the teacher" (individual skill, effective interaction with students, comprehension of a course material), the second – "Overall performance of chair" (the general organization, modern methods of teaching, feedback, interaction of students, the equipment, compliance with the syllabus), and the third – "Usefulness of training" (compliance with the program, usefulness). Separately there is a quality of food and printing materials.

According to the ranging of factors, individual skill of the teacher and overall performance of chair have the greatest weight. The management aimed at the solution of these problems will have the greatest impact due to the result of factor analysis. Usefulness is also a suf-

ficiently important factor, which demands special attention, taking into account the results received earlier.

We research the possibility of forecasting the "General impressions about provided training" parameter, trying various algorithms of classification in the KNIME data mining platform.

A scale change for the field "General impressions about provided training" for the purpose of increase in frequencies by possible versions of the answer was carried out:

- values from 0 to 6 were coded by 1 (Bad),
- from 7 to 8 – 2 (Well),
- from 9 to 10 – 3 (Perfect).

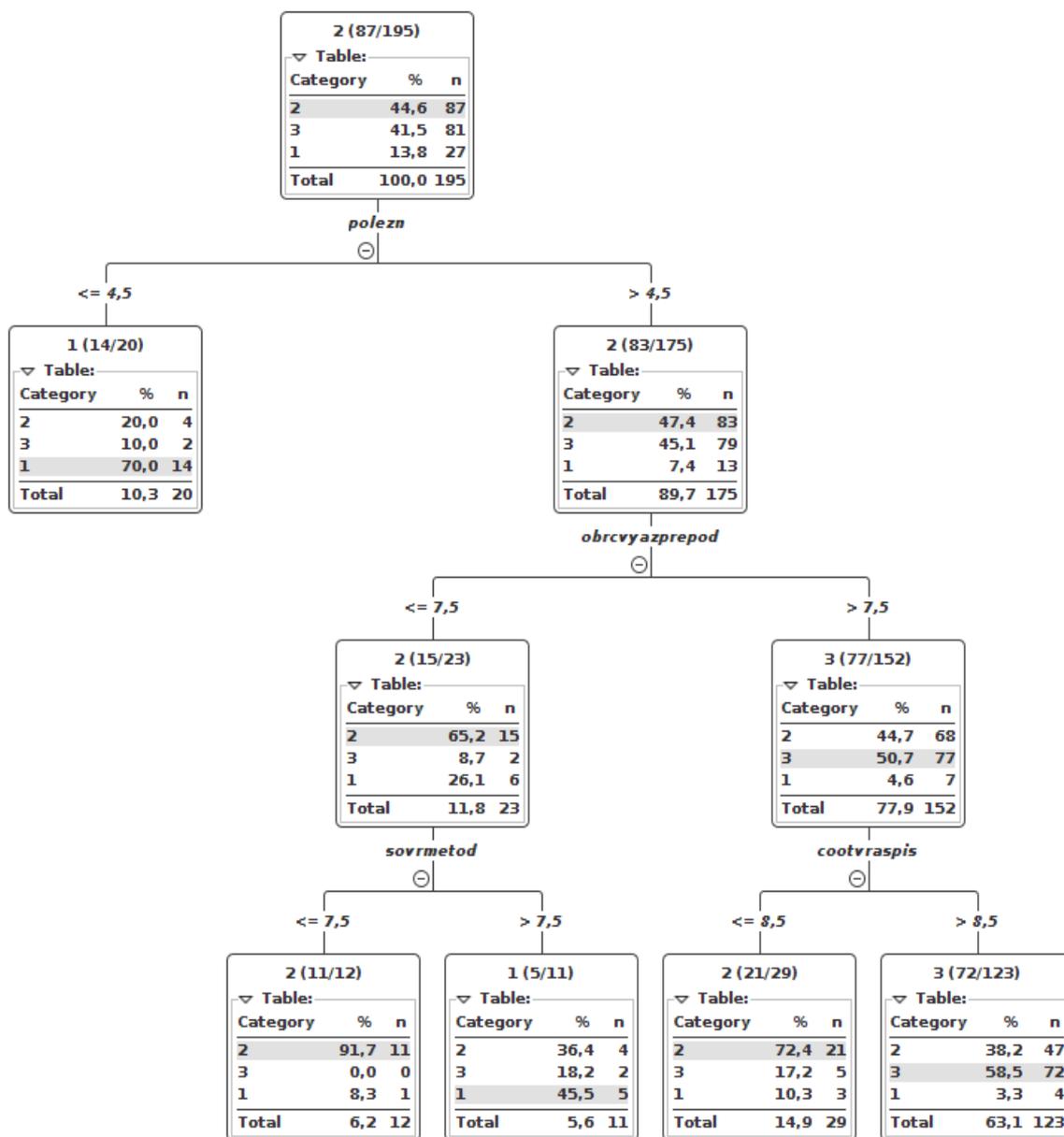


Figure 8. Decision tree, using "General impressions about provided training" as target variable

The result is not really impressive: the best accuracy in cross-validation by the leave-one-out method is 63% given by the decision tree algorithm (a quality measure – gain ratio, the minimum quantity of records per node is 10). The value of F-measure on 20% test dataset yielded a rather good result for class "1" (0.8) and satisfactory for classes "2" and "3" (0.6 and 0.632, respectively, which is explained by low specificity of class "3" – 0.565 and low sensitivity of class "2" – 0.529). The resulting model provides structure of course scoring by participants in general (see Fig. 8).

So (Fig. 8), about a half of students (17 of 24), scored from 0 to 6 "General impressions from a course" marked a course useless for themselves (marks lower than 5 points for "Practical usefulness of the carried-out training").

On the other hand, the usefulness was estimated at 9–10 points, feedback with chair at 9–10 points, compliance of occupations with the schedule at 9–10 points, with the teacher at 8–10 points giving to feedback in the general impression at 9–10 points (84%, 36 of 43 students).

If, when performing all previous conditions, usefulness is scored in the range from 6 to 8 points, the main role is played by food quality and the general organization of the process: the food quality scored at 8–10 points and the general organization, estimated at 9–10 points yields the result "Perfect" (73%, 19 of 26 students). If food quality is scored at 7 points and below, the result in most cases is "satisfactory" (78%, 14 of 18 students).

Other ranges of the factors stated above yield an unstable result in view of small frequencies.

3 Summary

On the basis of the analysis carried out, it is possible to formulate the following recommendations:

- To focus attention of students on thoughtful filling of the questionnaire as a large number of questionnaires go to waste and the final reduces to 40% from the original number.
- Electronic form of testing will be applied and new fields must be added (age, experience, education, and so on), because quality of the prediction model is low. Questionnaire anonymization is needed.
- Prime parameters for improvement can be allocated: "Existence, quality, usefulness of printing materials," "Quality of food in the dining room," "Practical usefulness of the carried-out training," "Equipment of educational audience," "Comprehension of a course material," and "Individual approach to the student".
- When hiring teachers, it is worth paying attention to readiness to work in a schedule grid, the maximum aim at individual work, effective interaction with students.
- Food, the general organization of process, and effective feedback with chair are capable of increasing the general satisfaction of students significantly.
- Especially, it should be noted the importance of factors: "Quality of food in the dining room" and "General organization of training process" when the usefulness of direct courses is not obvious to students.

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PROJECT MANAGEMENT IN RESEARCH AND DEVELOPMENT

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Abstract: Implementation of R&D projects determines whether the organization is changing and becoming fully competitive. R&D projects are the basis for innovation policy at the macro level – the state – and the micro level – the organization. Management of R&D projects requires not only high level of skills, but knowledge of highly developed tools to support the development of the organization. In managing this type of project, methods such as management competence, talent and knowledge, knowledge of modern information, and communication technology, stand out. In this study the following issues are presented: analysis of decision-making processes of R&D projects, basic modeling methodology of R&D projects, and analysis of communication systems in project management. The final part of the article presents the problems of commercialization of results obtained from R&D projects.

Keywords: R&D projects, decision in R&D projects, modeling of R&D projects, the system of communication in the project, the project managers, the commercialization of the project results.

1 Proposals for research – development, characterization, and importance

In management science, different periods of research proposal development can be distinguished. There are calm periods of evolution, but also turbulent periods of revolutionary change. Certainly, the present is situated in the latter. It consists of the fact that organizations that have, so far, been structured, orderly (managed, objective, and hierarchical), and transferred to a new type of flexible management. Such flexible management, focused on objectives and results, is called project management. R&D projects are in the family category of both the hardest and most significant projects in the development of organizations and society. Managing this type of project requires commitment and knowledge; an ambitious challenge for everyone involved in the project. For R&D, each project has its own area of research. Depending on the nature of the project as a whole, the research part will have a different contribution.

Implementation of R&D projects determines whether an organization is changing and becoming fully competitive. The state and its government, which does not attach importance to such projects, is not an attractive partner for other countries. Such a state is not innovative. R&D projects are, in fact, the basis for innovation policy at the macro level – the state – and the micro level – the organization.

Management of R&D projects requires not only high level of skills, but knowledge of highly developed tools

to support the development of the organization. In managing this type of project, some methods stand out, such as management competence, talent and knowledge, knowledge of modern information, and communication technologies, as well as the ability to use both Management Information Systems (MIS) and Business Intelligence Systems (BIS).

R&D projects have a very broad meaning, including the business of creating new objects and changing the existing ones. The research carried out often ends up suggesting that the intended changes do not pay to be carried out. Procuring research projects tends to be too political, with parties who are interested in research because of public sentiment, especially after various decisions modifying economic life. Such research often results in a waste of public funds. Often parties implement projects as a first test of public sentiment, and only then take positions on the case. For example, a public opinion survey on the implementation of innovative projects, such as the construction of a nuclear power plant.

All organizations are interested in projects that will enable them to become competitive. Projects may include, among others, organizational change, technology, and marketing, including the introduction of new products or services. The result of the project is to obtain new products, e.g. different types of mobile phones or devices for copying documents. R&D projects can be as simple as writing a transition to college, or a Bachelor's or Master's thesis, but they can also be complex and require the cooperation of teams from many

countries (projects global), and the disposal of huge financial resources. One example is an R&D project, implemented in 2012: Flight to Mars, the purpose of which was to take pictures of the Red Planet.

We conclude that a project is a system of activities characterized by the following triad: project scope, deadlines (time), and resources (human, capital, material, technological, information needed for the project). Sometimes the aforementioned parameters characterizing new projects are added, such as criteria for quality, cost, or risk. In the literature it is written as the characteristics of the project, such as uniqueness, complexity, and traceability. These features in the case of R&D projects are always present. Just as it is said, 'do not enter a second time into the same river,' so a second identical R&D project is never implemented. Conditions change. The people are not the same. Sometimes these changes are large, sometimes small. The complexity of the problem is not unique.

Each project has a primary objective in the implementation and support of specific goals. The general terms of a project, however, are not always congruent with R&D projects. R&D projects are carried out in conditions where it is often difficult to determine whether a goal has been achieved. Therefore, there are frequent cases of disagreement between reviewers reporting on projects in various competitions. M. Trocki [45] notes that there are high-risk technical, organizational, and economic factors in projects. It is good if we can determine the probability of achieving the project, expenditures, and execution time. The consequences of the absence or scarcity of research in the procedures of the project make its costs grow, even to a very large extent, such that sometimes it will not be realized at all.

The task facing the implementers is often the analysis of the relationships in the selected area of reality. This is consistent with the principles of system analysis, according to which the R&D project is an open system of actions, in which we analyze all of its elements and the relationships between them. The overlapping relationships are diverse in nature. One of the most important is feedback. The project, by obtaining partial results, verifies earlier hypotheses that can be corrected in the next stages of work. During this procedure, hypotheses are put forward by other researchers. You can also transfer results obtained during the implementation of projects in the field of basic science into practice. The earlier you check the correctness

of the results, the lower the potential costs in making the necessary adjustments.

Due to the nature of the work and the final result, R&D projects can be divided into:

- 1) Soft: those projects whose implementation is based on the presentation of reports, or semantic computer models, and other studies in the discovery of new relationships, patents, or improvement of techniques and technologies used. The result of these projects, according to the value chain, can be further researched.
- 2) Hard: projects in which the goal is defined as a product presented in the form of a pattern or the finished product. Here, too, there is a value chain, which results in an improved prototype in future projects.

The National Science Foundation (NSF) defines three types of R&D, namely: basic research, applied research, and R&D. Basic research is the primary aim of acquiring better knowledge and understanding, without a focus on practical application. According to the terminology adopted by the Central Statistical Office of Poland (<http://definicja.net/definicja/Gus>), R&D is considered to be systematically conducted creative work undertaken in order to increase the stock of knowledge, including knowledge of man, culture, and society.

According to the presented ideas, we assume that R&D projects are defined as the realization of a particular purpose, not always precisely worded, allowing new knowledge about the reality that surrounds us, to which end we have the necessary resources, including a highly qualified team of contractors. The project must be achieved at a given time, while being aware of the risk (sometimes high), and the assumed parameters. We are also aware that at the beginning of the project, all is not completely identified, and the parameters of the project will only be clarified during the work. Management of the project aims to develop the response posed by the initiator (sponsor). The objective is to increase the intellectual capital of individual researchers and teams, and the result is the development of theoretical and practical assumptions, plans to create a new product or service, as well as the development of principles of a new project. Often, the initiator is also the manager of the team performing the project. Often work organization is amorphous (i.e., sponsor, manager, and producer are the same person).

R&D projects have a good chance of achieving success, if they meet the following conditions:

- the project is relatively new (no one had realized such a project before),
- there is a very clear goal of what needs to be achieved,
- researchers with appropriate expertise and strong track record are involved in the project,
- the project is consistent with the strategic approaches developed, depending on the context: organization, region, state of the European Union, and the world economy.

If these conditions are not met, it is likely that it will be very difficult to achieve success in implementation.

2 Decisions in the implementation of R&D projects – the concept and typologies

In each phase of the research project, a number of decisions are taken. Some of them are more important from the point of view of the objectives, others less so. Activities in this field are supported by the decisions that are taken on their own, forced or taken by someone on our behalf. The concept of ‘decision’ (Latin *decisio*) has two basic meanings: result (narrow) and function (wide). Decision making is understood as the non-random selection of one of a set of possible options. The decision in the second, broader sense is understood as the process of deciding, which consists of: evaluation of information, decision-making problem identification, selection criterion decision, and determination and registration information for its execution.

A common platform for decision-making problems is derived from the work of the 1978 Nobel Prize winner, Herbert A. Simon [40]. This is sometimes called the Carnegie School approach from the name of the university where Simon worked. His concept of bounded rationality criticizes the concept of economic man (*homo economicus*), who decides only in his own interest. The approach of the ‘homo economicus’ decision maker is based on not having complete information about the problem of decision making, as all the possible options for solutions to the problem and the consequences of their application are not known. Its objective is to maximize the utility and ability to rank the options to be implemented according to the probability of success. H.A. Simon, like most of the people involved in decision-making theory, believed that

the decisions are made by decision-makers with limited opportunities to formulate a set of possible alternatives, and the consequences of their discernment forms part of its adoption. Hence the action makers – project management here – are not fully rational. In practice, the first chosen course of action that meets the criteria and the expected results, are good enough for the decision maker. The decision is a derivative of the objectives pursued and the tools to reach it.

The decision-making process (DMP) can be divided into seven elements such as:

- decision-making situation (decision problem) – a situation in which an entity (decision maker) is faced with the need to select one of at least two possible options for action where appropriate decision making is a set of options or conditions affecting the pursuit of the decision,
- decision maker – individual or group of individuals who decides or selects the final variant of decisions,
- the reason for the decision – perceived by the decision maker as a threat or as an opportunity; general situation that requires a decision,
- the purpose – the desired state intended, which is achievable through the implementation of the decision,
- the subject of the decision – with what is the decision concerned, which spheres of activity,
- user decision – person(s) for whom the changes caused by a decision may be relevant.

The decision in R&D projects is to select one of a set of capabilities to achieve the objective, related to all phases of the project, which consist of at least two competing elements. This process of selection is called DMP. Decisions affect a variety of factors such as tradition, convenience, experience, State guarantees, etc.

From a formal point of view, the DMP in R&D can be represented by the following:

$$PD = \{P, S, W, H\}$$

where:

P = the decision-making body, which must decide on the establishment of the project and decisions regarding its implementation; decision-maker has the right to decide, bears the responsibility for it and is interested in its implementation,

S = a set of decision-making situations, i.e. a set of conditions; these are the conditions within the organization or in its surroundings, where a particular deci-

sion is taken by considering the so-called terms of decision-making in accordance with the principles of the golden triangle: scope, time, and budget,

W = a set of results, to be able to select and determine whether the right decision has been taken, we need to know how it will end; the results depend on both the company's decision-making, as well as certain conditions (the conditions),

H = a set of hypotheses about future situations involving both the terms of the project, as well as influencing decisions on its implementation.

In DMP, one should have knowledge not only of the existing conditions, but also about how they will shape the future. We can distinguish the following situations:

- 1) Decision making under conditions of uncertainty.
- 2) Decision making under risk. Risk for the condition is considered to be a situation in which the elements influencing the decision are known with a certain probability.
- 3) Decision making under uncertainty. This is very much the situation occurring in projects, especially if they relate to strategic issues.

In practice, this also concerns deterministic and stochastic situations in decision making. The last two situations mentioned above define a common term: stochastic decision. The decision must be remembered in the existence of competition. Competitive projects can be changed at any time, and the rival can modify its earlier decisions and try to anticipate the decisions to be made by his competitors.

The implementation of many R&D DMPs are evaluated, controlled, and supervised. Function is performed by the evaluators. The natural way is to become their sponsors (stakeholders).

Evaluators use different evaluation criteria. The variety of decisions often leads to groups, classified by identifying some common characteristics and conditions. With the separation of the different types of DMP, it is easier to manage the project, train and improve decision makers, build specific procedures to assist managers, and rank performers. The classification of a decision for a particular type allows a more effective search algorithm, or heuristics, as well as highlighting decision risks, errors or traps specific to the type. The extent of the impact of the decision can be: economic, technical, information, personnel, production, and organization.

Because of the seriousness of the case and place in the hierarchy of project management, decisions can be strategic, operational, and tactical. Traditional management functions are distinguished by planning decisions, organizational, coordination, order giving, control, and motivation. Decisions may be taken both by individuals as well as by groups of people. Their specificity, often called psychological and sociological considerations, can distinguish several types of decisions that could significantly affect the operation of the project management system. These are often described as balanced, impulsive, passive, risky, and cautious.

To take the best decision from a set of possibilities requires the use of a variety of tools. They have a different form. Some are complex, while others are quite simple, such as, the model of a garbage can. It is used to make decisions in a situation of high time pressure and high complexity. The model name suggests the disorder, the lack of clear rules, and randomness (chaos) refers to the principle of trash in physical terms. The author of the theory is M.D. Cohen [34].

A contemporary tool to assist DMP is Information and Communication Technology (ICT). The problem of tools to support decision making is a wider problem, influenced by the type of decisions for which they are to be useful. In the DMP in the course of the project we have to deal with the chain of decisions. In making the first decision, we should consistently take all subsequent related decisions.

The results obtained after the first decision affect the next. Such models are called decision-making dynamic models. In contrast, the studies of specific individual decisions include static models. DMP, in which all stages of the design are strictly defined, is called algorithmic, and the method of its implementation is defined as an algorithm.

Heuristics is defined as the discipline dealing with methods of solving problems under conditions of incomplete information. The heuristic approach is offset by the lack of information, intuition, and experience. The use of heuristic methods needs the ability to locate and detect the facts and relations between them. Most of the discoveries, inventions, and unconventional methods of operation are achieved by heuristic techniques to solve problems.

Table 1. Selected project management features supported by formal models

Management Features	Mathematical Quantitative Models					
	Optimization	Simulation	Econometric	Predictive	Theory game	Theory graphs
Forecasting	X	X	X	X	X	
Programming	X	X			X	
Planning	X	X	X	X	X	X
Coordinating		X				X
Monitoring		X	X			

Note: X indicates that the function is particularly often assisted by quantitative methods

The general characteristics of the situation seem to be useful for programmable decisions only. Programmable decisions are taken in relation to projects with a clear structure, in which the problem is clearly defined. In practice, a hybrid approach is required, that incorporates both algorithmic and heuristic elements.

Mistakes, or the existence of new reasons, make it necessary to change the decision. If these are seen after the implementation of the project, then assume a much higher repair cost than shown in the initial steps. It is also assumed that the cost of repairing errors grows in an exponential manner depending on the time of their discovery.

3 Modeling of R&D projects – methodological basis

Decisions before they are implemented in the real world should be checked in the virtual world, i.e. modeled. What is the model? According to W. Findeisen [10], it is an ambiguous concept. Typically, the model is understood as a certain image or pattern. Sometimes the model is identified with a very broadly defined course of action. The project model and implementation process is a simplified picture of reality, because it focuses on what is most important. Its construction is based on system analysis, or a set of elements and relations between them. The costs of mistakes in the world of models are much lower than those in the real world. We take care of a particular class of models, namely models of managerial decision making. Decision models have different designs and are both mathematical models and structured. The specific practical situation requires modification of the base model and its adapta-

tion to the real situation. It could be argued that, in practice, no two models are ever the same.

A decision model is a concept in the theory and practice of management. It shows the mapping of the whole or part of the reality that synthetically describes the decision problem (see Table 1). Its task is to define a set of permissible decisions, evaluation criteria, and the conditions of implementation, to be able to select a set of optimal decisions, if such solutions exist. In practice, the project management of R&D strives to create models with the greatest possible participation of formal elements. Due to the interdisciplinary nature of the decision-making processes in the implementation of R&D projects, it happens that the applied models are statistical, econometric, economic, and semantic. There are also models that can be classified as psychological and philosophical.

Before we start to build the model, we need to formulate the decision problem. The conditions that were adopted in the formulation of this problem, also become the DMP assumptions. Sometimes, there are two types of DMP models, conventionally called classical and managerial. In the classical model, there is a belief in the possibility of optimizing the decision. It is believed that rational, reasoned, and systematic actions are conducive to finding relevant solutions to problems. The managerial model explains that it is practically impossible to make optimal decisions, but you must strive for such a solution. Therefore, the project manager and his team should seek to obtain full information about the decision situation and seek to minimize risk. Such activities need to have a broad set of information. This form of decision making uses the experience of the expert team and tools such as mind mapping and brainstorming.

The hard approach, which we call engineering, seeks to ensure the model is accurate and unambiguous. It is created using modeling languages and computer programming, as well as formal techniques. In practice, the packages used are computer-specific, such as, ‘Statistica’.

The basis of the modern approach to project management, irrespective of its use, are mathematical or other models, which also seek formal analysis of the project at all stages, but they have a slightly different structure and other features. We call them structural models. The name of this type of model comes from a focus on the presentation of project structure, in order to present them according to the existing system approach. As a result of analyses, hierarchical or network structures are created, which are data elements, features, and the relationships between them. This approach is currently dominant in project management.

The construction of structural models uses a number of techniques detailed in the literature and recommended design methodologies. Often, their job is the most accurate presentation of the situation and the decision provided to the project. To serve this purpose, specific techniques are included, such as: block diagram data flow, entity relationship modeling, and UML models used in the approach of ARIS [11] and ADONIS [48].

To build the model, it is necessary to use a specific notation record. Just as the semantic model is written using a specific language, using a dictionary and correct grammar, structural models for the description of the project also use a variety of notations for their construction. The simplest and probably oldest model used in the presentation of the processes occurring in the implementation of R&D projects is a block diagram.

In practice, we use hybrid models. In these types of models, there are both formal and heuristic elements. Such models are used in advanced projects. Two examples are given below, each model having different uses and structure. Both can be assigned to the class of structural models.

In the first of them – Mind Mapping – principles of graph theory are applied, while the second uses a tool to support applied statistics and econometrics. Mind Mapping is used for a variety of work-related R&D projects, especially for creating documents in procedures and formulation of decision problems. The result of the application of the model is – accord-

ing to its creators – to work together to increase the efficiency of the system and to improve communication among teams.

Another representative of hybrid models is the Technology Acceptance Model (TAM). This model has an advantage over quantitative quality tools. We use the TAM to investigate causal relationships that occur in the project. The author of the TAM is F.D. Davis [7]. This model is used in the explanation of technological solutions adopted in R&D projects. Theory and models have been developed based on the Theory of Reasoned Action (TRA) [3]. TRA assumes that the final user’s behavior is the result of his beliefs, fears, and hopes. This means that the more a person is convinced of the rightness of the selection tools, and hopes that it will help them work better, faster, or with less effort, the easier it will be to accept new technologies for project management.

In the process of analysis models used in projects, we would like to draw attention to the models used in the management of selected stages of this type of project. One of the most important steps is to define the R&D project. Two of the most useful models used in this stage of project management are the Work Breakdown Structure (WBS) and the logical framework. The use of this type of model is required in the majority of R&D projects, whose creators seek funding from the European Union.

The stage of the project can recommend the implementation of these models to support the implementation schedules, determine the critical path, designate milestones, and allow for resource management, as well as optimize the duration of the project.

Scheduling is a common tool for project management support. Basic information contained in the schedule shows the relationship between the activities carried out in the project. Schedules for R&D projects have their own specifications. The applications can be distinguished as follows:

- static models, such as an illustration of a graph (model) using a Gantt chart, is a graphic representation of the steps of planning and control of the project, often referred to as a technique of beam diagrams,
- dynamic models, also called network diagrams; the term covers models such as Program Evaluation and Review Technique (PERT) and the Critical Path

Method (CPM), developed by the company DuPont for control of large and complex industrial projects.

Regardless of the model presented previously, business models have a special place. In fact, in the business model, analysis should begin with the presentation of the selected item within the sequence of models used in the management of R&D projects. Implementation of the project always requires resources, and thus, we need to look at the R&D of the business side. This is an important but difficult problem.

We agree with D.J. Teece [43, p. 175], who says that ‘good design is the art of business models.’ The popular definition of the business model proposed by A. Afuah and C.L. Tucci [2, p. 20] is that the ‘business model is adopted by the method of zooming in and use of resources in order to provide customers with products and services whose value exceeds the offer of competitors and while ensuring the profitability of the company.’ In simple terms, we can say that the business model describes the way in which R&D projects are to make money or be financed.

In most of the analyzed types of projects, maintenance problems occur in the initial stage, then depending on the result, come issues of commercialization of the results. The issue of commercialization will be the subject of the last section.

4 The project managers and their role in the project

Building a team to carry out an R&D project, we create (cf. [22]) human capital organization or intellectual capital, which are basically the same thing. If we used morphology success factors of projects, in the first place we would find a man. Therefore, it is reasonable to say that one of the most important factors affecting the success of any project is the human factor. Human resources policy depends on whether the project will be implemented in an efficient and economical way. In the literature, there are many books and monographs on social potential management, management of social capital, and intellectual resources of the organization. All management schools devote a special place to this problem.

The specificity of the action of project management happens in a constantly changing environment, where decisions are risky. Human Resources management policy in research and development should follow some basic rules:

- volatility of the situation and the need for permanent modification of assumptions and behaviors,
- work in specific time intervals (or stable employment dilemma to some extent uncertain),
- special role of the project manager – often the creator – in the project.

Management of and work to implement projects carry a wide variety of challenges. Many contemporary projects have been created in a multicultural environment. Traditional procedures, such as management, recruitment, selection, conflict resolution, and talent management require a slightly different perspective than is given in the traditional monographs in this field.

The work of the project manager has many features in common with the typical work of the team leader in the traditional functioning of the organization. His work, however, differs from that of the traditional head of the organization in several key aspects. First of all, the work of the project manager is to implement a unique project, involving a temporary working group. Employees are recruited from an organization that is interested in the results of the project, or from other organizations, often through the activities of recruitment of cells of different organizations. The aim of the project is to create something new, unique, and therefore, to achieve these objectives requires very good cooperation between the principal, the contractor, and the beneficiary of the project. Thus, the project manager should be both a politician and negotiator.

J. Szaban [42] and R.A. Webber divide the power as:

- legitimate: derived from the belief that to hold power you just have to listen, because the manager has the legitimacy to exercise authority and has the appropriate qualifications,
- traditional: resulting from customs not always stored in the work regulations and other legal acts,
- expert: listening to someone because of their knowledge and the skills by which they exercise authority over others; this type of power is the most desirable for the project manager,
- charismatic: resulting from the specific qualities of a person having authority, such as having a vision and ideas.

The head of a R&D project should have all of these types of powers, but the most important is expert and charismatic authority. Charismatic leaders are sometimes referred to as transformational leaders.

These leaders should also have such features as: intelligence, social skills, persuasiveness, prone to dominance, ambition, and aggressiveness. Use of the term ‘transformational leader’ highlights the role of the project manager in inspiring, marking out new ambitious goals, motivating people to their implementation, and leadership.

Each R&D project is an ‘unknown’; its implementation requires courage. The project manager is the person who is aware that not everything can be foreseen and that project management is associated with the risk of losing a professional position, embarrassment, and sometimes even their own lives. Ideally, it is demonstrated in experimental projects, which could include those aimed at the study of new types of aircraft, parachutes, or nuclear reactors.

The project manager is trained for times of crisis, because they have a chance to show their charisma and skills. R.K. Merton [24] made the following distinction among project managers:

- people who have an impact on the team at the moment, and their social position are fixed,
- people potentially affected (rising stars, climbing up the social ladder),
- people whose influence gradually disappears (after reaching the summit, they descend the social ladder),
- people whose influence is ‘hidden’ (the person exerting influence has objective qualities, but does not use them).

Using this typology, we can conclude that the project manager of R&D is from one of the first two groups of people. He is head of the project team. According to H. Schelle [39], the project manager is the person responsible for the project; organizing the team, and for the management, planning, and monitoring of the project. His task is to create the conditions to achieve the goal or goals.

Tasks and services performed by the project manager are different from those carried out by other members of the project team. The project manager directs the work of others. They also perform the tasks as instructed, teach, or give directions. In this way, they develop the skills of employees. The manager-staff relationship is basically that of a coach, where the manager shares his experience with the person to be trained.

H. Mintzberg [47] developed a system that, even after many years, is still termed ‘according to Mintzberg’s

managerial roles.’ Under this system, all managers implementing the project have a triple role, namely:

- interpersonal,
- informational, and
- decision making.

The project manager works in an ever-changing situation, both internal and external. Theories of management science are termed scientific management, behavioral management, including the psychology of work, and system management. The use of all approaches to solve a particular problem is defined as integrated management.

The project manager must be sensitive to this, in order to create favorable conditions in which the project is carried out as efficiently as possible. In most cases, the worker is working in order to meet specific needs. W. Kieżun [13] states that the minimum management skills needed are: intelligence, mental strength, a certain level of morality, as well as a predisposition syndrome called managerial talent and sense of organization.

As pointed out by M. Romanowska [37], the manager shapes a new profile. The complexity of management causes a significant increase of demands on him. This new situation creates increasing difficulties, requiring an increase in the skills and competencies of managers and non-traditional systems to fulfill their leadership roles.

5 The system of communication in the project

The basic task of every project manager is to answer the question: How do you organize teams performing R&D to create the conditions for strengthening effects of working together, to allow full flow of information and knowledge within the team? Successes and failures of many projects depend on various factors. The most important is communication. It has a very large impact on the final effects.

One also has to deal with the mutual relations between internal and external communication systems. The advantage of the research presented in the literature concerns the analysis of external communication systems, usually the design team’s relationships with the environment.

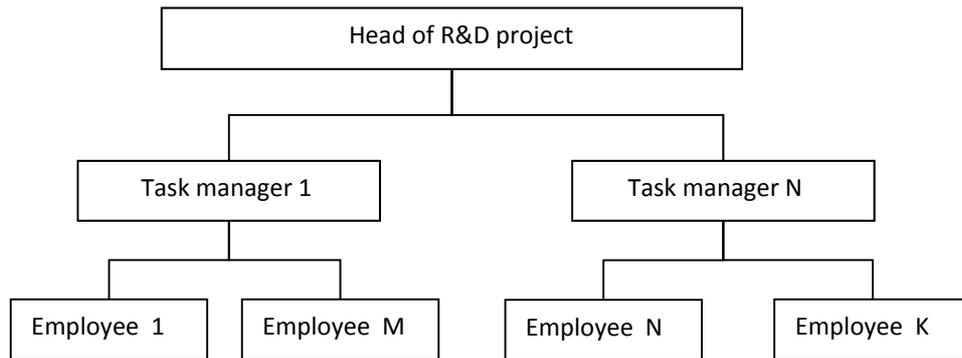


Figure 1. Hierarchical communication system

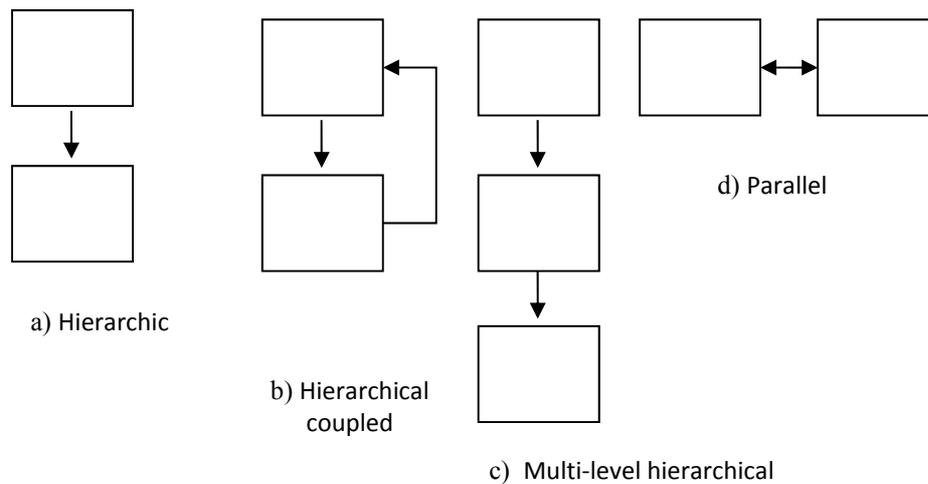


Figure 2. Relationship between individual employees in the project team

An analysis of publications in the field of building design and effective systems deserve special attention, since tests involve the analysis of the basic contradictions inherent in project teams (O. Stawnicz, K. Kurbel [41], D. Wehrenfennig [46]). L. Mullins [26] points out that the leaders of project groups of employees require both willingness to compromise and subordination, as well as high level of individualism and creativity. J. Chaffe [6] says that most people in the course of their work lose creativity and individualism in favor of conformity and mediocrity. Therefore, you will notice the tendency to form teams made up only of young workers, despite the absence of their professional experience. Consequently, you should reconcile to these contradictory tendencies and choose the most competent employees in order to minimize the risk of failure.

J. Adair [1] points to the three criteria that should be taken into account when selecting the design team: competence, motivation to work, and personal attributes. More specifically, before the task of organizing

the communication system, the following question should be asked: What conditions should be created for the functioning of project teams to:

- minimize the negative effects of working in a team,
- strengthen the positives of this cooperation.

In fulfillment of tasks by project teams, different styles of management can be applied, and within them different systems of delegation of tasks and assessment methods for their implementation. Many project teams have used a traditional, hierarchical communication system as shown in Fig. 1. The communication system in the project team is made up of different types of 'bricks' or work stations. Basic types of connections are shown in Fig. 2.

Information System efficiency is dependent on the operation of the bricks, as well as the deformation associated with the operation of various types of noise in an information channel.

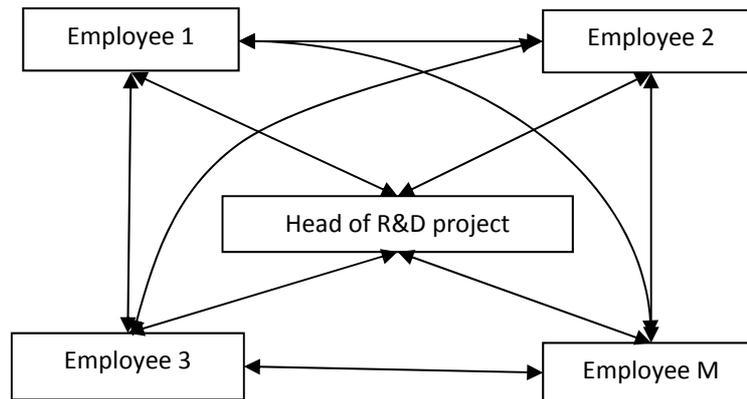


Figure 3. Network communication system in small teams carrying out research and development projects

The deformation is caused by factors such as:

- technical or computer, where existing infrastructure is unable to cope with the form and content of the transmitted information,
- semantic, that is when our recipient, usually with inadequate qualifications, cannot read or interpret the transmitted information,
- pragmatic, when the information received does not give anything new to him, and the recipient has lost time and resources to its acquisition.

Inefficient systems, shown in Fig. 2c, are characterized by long-term communication and the relatively large losses in the channels of information. Also, a system in which the employee receives only commands without feedback, illustrated in Fig. 2a, is not to be recommended. Such a situation does not occur in practice. There is always a feedback loop in which the subordinate employee provides information on the progress of the resulting task. However, as shown in previous works by J. Kisielnicki [14, 15], the relationship of dependency makes it difficult to absorb knowledge.

The employee is usually very reluctant to transmit knowledge to his leader. We can say that the employee considers it his duty to provide information only, rather than transfer his knowledge of the project. G. Morgan [25] writes that, in the organization, hierarchy is a source of various types of competition between workers. The game is played on the position of workers in the organizational structure. Based on surveys (J. Kisielnicki [14, 15]), it can be stated that the situation is different if employees work together, and the evaluation of their work is related to the evaluation

of completed tasks together. Cooperation in such circumstances becomes a necessity. Between employees there may be a significant transfer of knowledge (J. Kisielnicki [16]).

Tasks that occur in projects can be divided into two categories:

- 1) The implementation of tasks on technology purchased or installed software needed for research, as, for example, Statistica Data Warehouse. The most important is the strict implementation of so-called 'good' procedures. As practice shows, there is variability in business processes and project environments. This requires research projects to modify existing applications or existing processes to fit the reality.
- 2) Research tasks that require working in new and unique conditions, in which we have to use creativity and knowledge.

Therefore, keeping in mind the mentioned limitations, a network communication system is effective when it is determined by the performance of each point of the procedure

A network communication system is a system in which the relationships between the design team participants are direct. In such a situation, the role of the project manager is to build the system of information and knowledge, as well as the construction of a system of mutual trust between team members.

In practice, as shown in Fig. 3, network communication systems are used in a more complex form. Such situations are possible in small, five to seven person systems design.

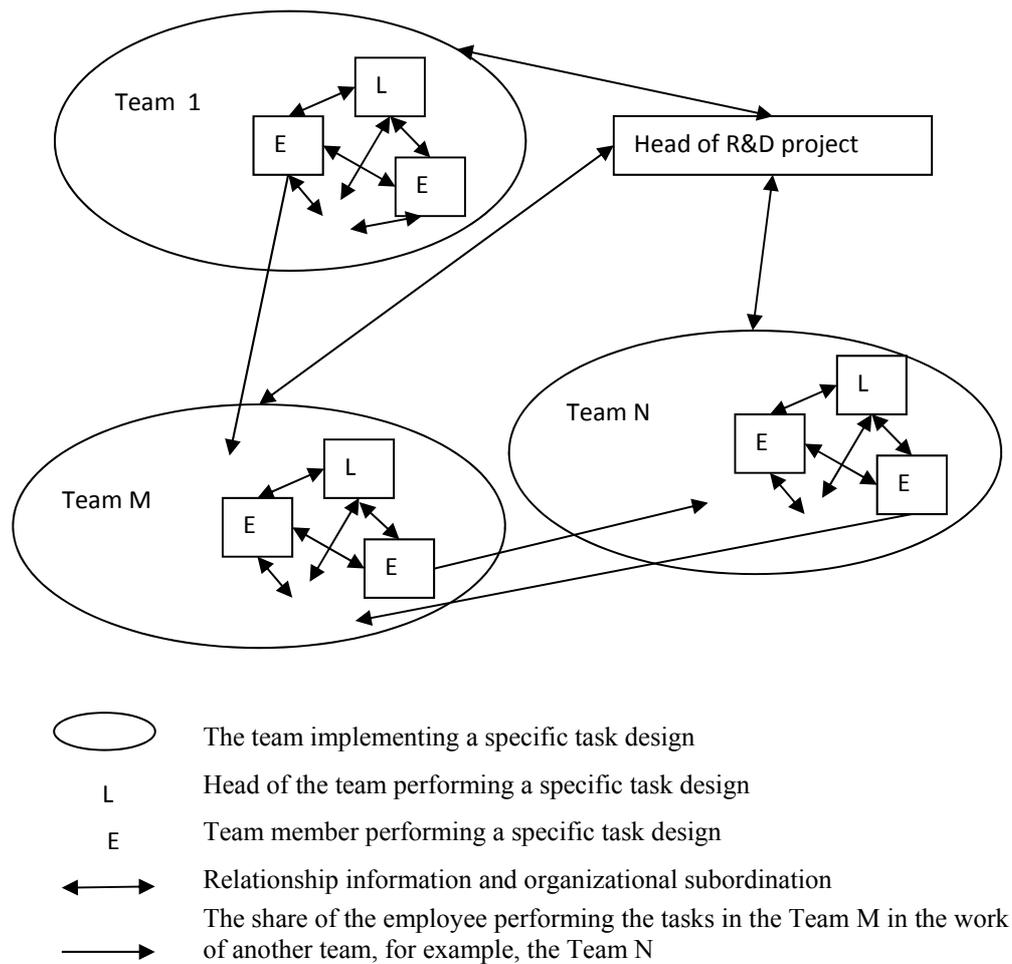


Figure 4. Organizational structure and communication scheme in an organized network-large project team

This system was tested by the study author in the implementation of several complex R&D projects in the Information Technology (IT) industry. It has been well received by the persons carrying out the project, and what is most important, it has proved to be effective and efficient.

Organizational structure of network communication, as shown in Fig. 4, can be characterized as follows:

- 1) Division into task forces that change dynamically during the execution of the research project.
- 2) The only person coordinating the whole process is the project manager (Fig. 4). Persons acting as individual task managers have a dual role: being the task manager and the designer (clerical).

The projects examined by the author (J. Kisielnicki [18, 19]) changes in rotational job as a manager of the project, if the situation was announced at the beginning of the construction team and met with understanding. Financial rules have also been fixed so that the position

of the head of the project was treated as a kind of duty, with rewards, but not as an additional source of income. Decisions about team changes were difficult due to two reasons: differences in the implementation of individual tasks and the time of formation of interpersonal relationships between employees. Getting used to work in a stable team is treated as an important element in promoting communication systems within the task force.

6 The commercialization of the project results

R&D projects should be applied in practice and benefit both the sponsors and the implementers. For this purpose, we use existing business models. Some projects bring economic or social benefits directly to others over time, some projects may produce patents, and others professional empowerment of the manager and project participants, through degrees or promotions.

Of course, getting degrees does not preclude advancement and often strengthens the competitive position of the project team and its members. Therefore, we need to consider this, as the results transform into money, or commercialization. A milestone in the commercialization of research was the Bayh-Dole Act, adopted on December 12, 1980 by the US Congress. This Act gave universities intellectual property rights to inventions and discoveries. (N. Kirov, A. Kuśmierz, [49]).

Commercialization is defined as all activities related to the transfer of technical or organizational knowledge and related know-how to economic practice. So, it can be defined as the process of market power of new technologies (in our results of R&D projects). Often, commercialization is deferred over time, because to commercialize, the project must first be implemented. In this part we deal with the problem of commercialization more, because we want to show the proposed arrangements for financing the implementation of R&D projects. The starting point of the commercialization process is usually an invention or produced results. This opens up new technical possibilities and research, by itself, has no market value. E. Rasmussen believes that the approach to the commercialization of research can be divided into two types: the American and Canadian-European. The difference between them lies not in legal regulations, but on the specific national markets.

In the US, there are some great companies interested in the results of research projects carried out in universities, but in Canada and Europe, this demand is not there. As a result, in these countries, scientific and research entities establish spin-off companies, thus creating a company to create and finance such projects. Spin-off companies are created in order to develop and commercialize the results of creative works, with the right to acquire and use of intellectual property and its protection among public universities. The capital of such a company often comes from different sources.

There are three basic ways to commercialize the results of research and development:

- direct sales results of R&D, which is the simplest, but also the least profitable form of marketing,
- license sharing of the results obtained, which is a more advanced method of commercialization and requires more effort due to the long-term nature of the relationship between the licensor and the licensee,

- bringing the results of R&D to the company, which is the most advanced form of commercialization; bringing the results of the project to contributions in kind which may be held in an existing company, as well as the newly formed, spin-off company (Pietrusiński R., Zawalonka-Cegielska J. [32]).

As the Ministry of Science and Higher Education notes in its documents, the sale of R&D is the least labor-intensive and least risky method of commercialization. It is also the method with the least potential to generate revenue. At the other end of the spectrum is a method that involves the input of a test facility to the company commercializing the results of R&D (or the establishment of the company). This is the most laborious and risky method, but has the greatest potential to generate long-term benefits.

The key problem is to decide on the legal form of organization, which is to commercialize the results. The form chosen should be linked to:

- determination of the number of entities involved in the project commercialization, such as state universities and private research institutes and research centers, and other similar type,
- choice of sources and funding model to implement the project,
- adoption of the most favorable tax arrangements for the activity in question,
- determination of the subject and form of management implementation process.

Selected legal forms should correspond to the assumptions and parameters of the target business model. Limiting the options of possible solutions of the many legal forms, we present the following forms: a government agency (state), a research unit, a foundation, or a company (joint-stock).

The aforementioned E. Rasmussen [36] distinguishes two periods of commercialization of research in Europe. The first – the start of the 1990s – was the so-called development of technology parks. The second period, which continues to this day, was the creation of spin-off companies, the sale of patents and licenses, and the involvement of students. In some Polish universities, for example, in the University of Warsaw, Warsaw University of Technology, Medical University of Warsaw, there are spin-off companies. A description of some of the types of companies as well as the problems they create together with the literature are given by J. Kisielnicki [19].

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LIFE CYCLE ASSESSMENT IN MANAGEMENT OF SOCIALLY RESPONSIBLE ENTERPRISE

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Abstract: The following paper presents dangerous and evident phenomenon of communicational chaos in the field of environment protection and sustainable development in a turbulent external environment. It is pointed that this phenomenon gives organizations an opportunity to take pretended pro-environmental actions, such as socially critical *greenwashing*. As a counterbalance to those practices, a concept of Corporate Social Responsibility (CSR) is presented, underlining the possibility of developing honest environmental marketing basing on methods such as Life Cycle Assessment.

Keywords: Corporate Social Responsibility (CSR), carbon footprint, greenwashing, management, marketing, communicational chaos, turbulent environment, Life Cycle Assessment (LCA).

1 Introduction

Constantly changing conditions of external environment intensify possibilities of unpredictable occurrences and in effect a threatening image crisis of an organization. Nowadays this is even more severe due to new technologies – the flow of information happens at almost the speed of light and events spread as fast as never before, causing tremendous turbulences [1].

Rapid pace of production and emphasis on lowering costs are accompanied by risk and uncertainty and therefore require a necessity of operational security. Organizations lean towards concepts such as sustainable development, which constitute a natural antidote for negative voices of public opinion and enable to rebuild frayed image.

Turbulent external environment is linked to clearly noticeable chaos – including communication chaos, which creates an opportunity to undertake pretended CSR actions in a form of *greenwashing*, dangerous from both environmental and social perspective. Successful method of countering such practices is promotion of more objective methods of environmental impact assessment, such as Life Cycle Assessment (LCA).

First of all, it should be emphasized, that LCA is one of the most objective study methods of environmental influences of organizations-enterprises, but actually

every type of people activity. Although it is never possible to eliminate so called human factor, connected with objects' choice, parameters choice, or individual interpretation, the endpoint of this kind of life cycle research are numerical results which enable relatively accurate assessment and comparison. Such numerical result would be especially desirable in sustainability and corporate responsibility studies, where we can observe clear lack of objective criteria and there are rather guidelines than rules mentioned. Sometimes a reference point for sustainable development become legal regulations: to obey the law, but very often it is not enough to be sustained.

According to all above questions, implementation of LCA, as a general method of system inputs and outputs investigation and as a useful research technique, can be very important for development of CSR and sustainability concepts, making a big contribution both to economic science and to practical management activities. In the future it should also be possible to avoid not only definitional or measurement problems but also such, described below, dangerous phenomena as *greenwashing* and other examples of *green noise* or informational chaos, especially connected with turbulent, demanding continuous competence confirmation, environment. It should also give the enterprises the best possible communication tool in accordance with the principle of transparency.

2 Essence of *greenwashing*

As mentioned, LCA results can be used for responsible and effective environmental communications, especially desired in the era of so-called *greenwashing*. Concept of *greenwashing* was coined in 1986 by ecologist Jay Westervelt in an essay concerning actions of hotel industry. Hotels recommended guests to dispose of their towels less often, allegedly taking the view of environmental awareness, but in effect this practice was imposed to reduce costs [2]. Horiuchi, Schuchard, Shae, and Townsend, authors of report called *Understanding and Preventing Greenwash: A Business Guide*, give two definitions of *greenwashing*. First one comes from the *Oxford English Dictionary* – “Disinformation disseminated by an organization, etc., so as to present an environmentally responsible public image; a public image of environmental responsibility promulgated by or for an organization, etc., but perceived as being unfounded or intentionally misleading.” The other definition was taken from *Lincoln Star Journal* and is more explicit – “little green lies” [3].

Authors of the report have also spotted so called “10 Signs of Greenwash”, which can be a confirmation of deliberate disinformation in the image creating [3]:

- 1) Fluffy language: words or terms with no clear meaning (e.g. eco-friendly).
- 2) Green product vs. dirty company: such as efficient lightbulbs made in a factory that pollutes rivers.
- 3) Suggestive pictures: green images that indicate a (unjustified) green impact (e.g. flowers blooming from exhaust pipes).
- 4) Irrelevant claims: Emphasizing one tiny green attribute when everything else is not green.
- 5) Best in class: declaring you are slightly greener than the rest, even if the rest are pretty terrible.
- 6) Just not credible: “eco-friendly” cigarettes, anyone? “Greening” a dangerous product does not make it safe.
- 7) Jargon: Information that only a scientist could check or understand.
- 8) Imaginary friends: a “label” that looks like third party endorsement-except that it’s made up.
- 9) No proof: it could be right, but where’s the evidence?
- 10) Outright lying: totally fabricated claims or data.

In other version of *greenwashing* analysis, there is presented another version of mentioned signs [4]. The list

is shorter and includes only six signs (only what should be emphasized), but general concept remains the same. Those six evidences of *greenwashing* have been vividly called sins [4]:

- 1) Sin of the Hidden Trade-Off – such claims are not usually false, but are used to *paint a greener picture* of the product than a more complete environmental analysis would support. This sin is committed by suggesting a product is *green* based on a single environmental attribute like the recycled content of paper, or an unreasonably narrow set of attributes, such as recycled content and chlorine-free bleaching, without attention to other important, or perhaps more important, environmental issues like energy, global warming, water, and forestry impacts of paper [4].
- 2) Sin of No Proof – environmental claim not substantiated by easily accessible supporting information, or by a reliable third-party certification. Example of such sin is: household lamps and lights that promote their energy efficiency without any supporting evidence or certification or personal care products that claim not to have been tested on animals, but offer no evidence or certification of this claim [4].
- 3) Sin of Vagueness – committed by every claim that is so poorly defined or broad that its real meaning is likely to be misunderstood by the intended consumer. Such sin of No Proof is very often connected with specific vague labels, like: chemical free or all natural. As a visual example vagueness sin there is mentioned the so called Moebius Loop (Fig. 1) that is designed to show, that the product is produced from recycled materials, but very often actual content of such raw material remains unclear, especially for the consumer.
- 4) Sin of Irrelevance – environmental claim that may be truthful but is unimportant and unhelpful for consumers seeking environmentally preferable products. It is irrelevant and therefore distracts the consumer from finding a truly greener option. The most frequent example of an irrelevant claim relates to chlorofluorocarbons (Fig. 2) – a principal contributor to ozone depletion. Since chlorofluorocarbons have been legally banned for almost 30 years, there are *no* products that are manufactured with it [4].

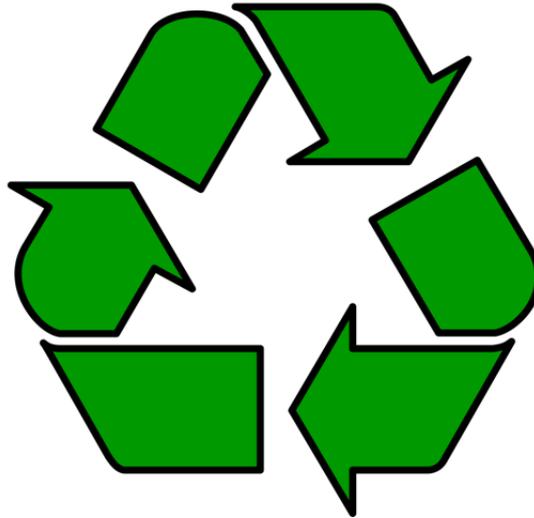


Figure 1. Moebius Loop–sign of recycling material content



Figure 2. No chlorofluorocarbons sign
(source: *Company Press Service*)

- 5) Sin of Fibbing – committed by making environmental claims that are simply false. In authors' findings, only a few products were found to commit the Sin of Fibbing. Most of these were misuse or misrepresentation of certification by an independent authority [4].
- 6) Sin of Lesser of Two Evils – claims that may be true within the product category, but that risk distracting the consumer from the greater environmental impacts of the category as a whole. Exam-

Examples include: organic cigarettes or *green* herbicides [4].

Percentage of documented cases of six sins of greenwashing presents chart on Fig. 3 [4].

As a result of *greenwashing* research, there were identified four types of environmental actions. Value to the environment and effectiveness of communications matrix is presented in Fig. 4 [3].

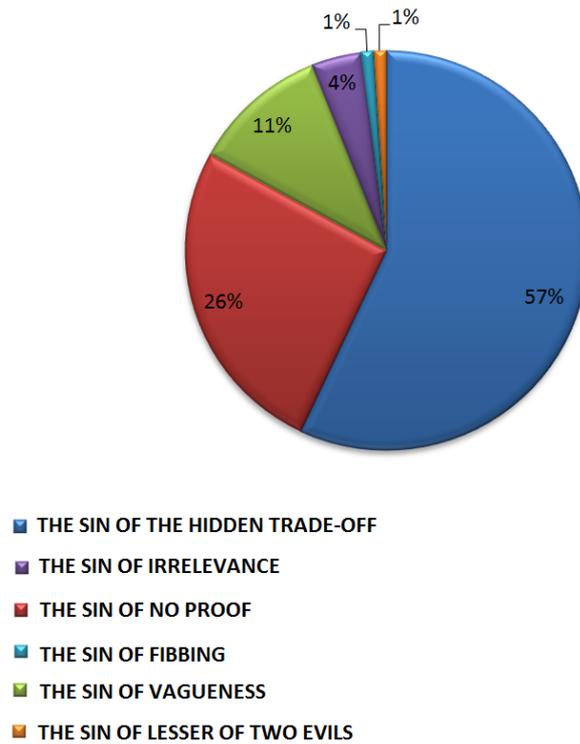


Figure 3. Six sins of *greenwashing*
(source: [4])

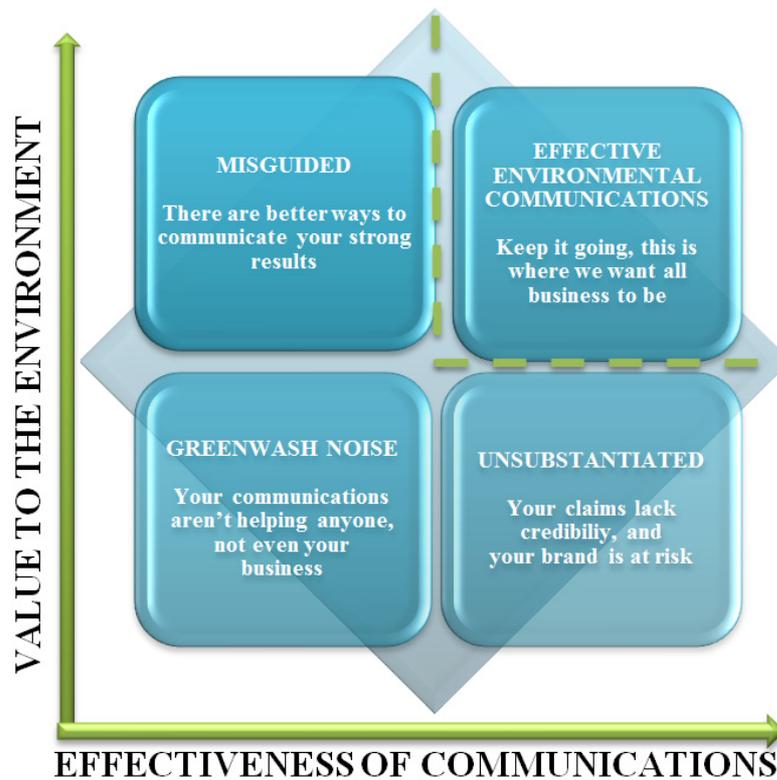


Figure 4. Value to the environment and effectiveness of communications matrix
(source: [3])

- **Misguided Greenwash**

This category includes companies that have made substantial efforts to improve the environmental performance of their products and processes but are unable to communicate these efforts effectively. These companies may be making sweeping generalizations in their claims to try to sound “environmentally friendly” or they may be using language that turns off potential customers. They have the potential to move towards the “Effective Environmental Communications” quadrant by focusing their messages accurately on key impacts backed up with data [3].

- **Unsubstantiated Greenwash**

At first glance, these companies seem to be doing commendable work and providing data to back up their claim. However, a deeper dive shows that the company does not deserve as much credit as it seems. It may be lobbying against the very environmental policies it claims to uphold, or it may be putting more resources into its communications than its actual initiatives. False efforts will eventually be uncovered as the public becomes more educated and sensitive to *greenwash*, and it is only a matter of time that these companies will be sent to the “*Greenwash* Noise” quadrant [3].

- **Greenwash Noise**

In cases where a company says, “we’re green”, but does not have much to back up this claim, these messages are not compelling to consumers. Much work needs to be done to move these companies to the top right quadrant, but it is feasible. By assessing the company’s impacts throughout the value chain, developing and implementing an environmental strategy, and then communicating these efforts accurately, these companies can create a path to the “Effective Environmental Communications” quadrant [3].

- **Effective Environmental Communications**

This is the goal we have for all companies. These businesses are improving the environmental and social performance of their products and aligning these efforts throughout various functions within the company. They are able to communicate their efforts so that consumers clearly understand the impacts, and other businesses look to these companies for leadership [3].

What is essential is that *greenwashing* does not only substitute honest environmental communication, but also, or possibly more importantly, becomes a social issue.

Primary addressees of all corporate environmental communication are called as green consumers. They exclude the following group of products from their sphere of interests [5]:

- Products harmful to health,
 - Products generating serious environmental damages during their production, use, and waste management phase,
 - Products causing excessive use of resources in their production, use, and waste phase,
 - Products generating large amounts of waste, containing resources from endangered species and ecosystems,
 - Products produced in a way that is threatening to animals or having negative impact on other countries, among others – developing ones
- Green consumers comprise of opinion-forming group of socially responsible leaders. Abuses in green marketing practices may negatively impact their decisions and choices. It is worth underlining that through environmental disinformation and over interpretation consumers and wider circle of organization stakeholders are as a matter of fact encouraged to act contrary to the rules of sustainable development. What is even more important is that in a global sense, gaining awareness of *greenwashing* practices of organizations can have a demotivating effect and discourage conscious consumers, from a given sector or market, to continue further pro-environmental practices, as they prove to be ineffective.

The assumption, that in such circumstances the most socially desirable – and also socially responsible – way is to promote solutions based not on intuitive feelings of consumers but on actual figures presenting seems to be justified. Also the world of science should be involved in creating such, as objective as possible, rules. It seems, an appropriate starting point here can be the LCA method with all its principles.



Figure 5. Carroll's model in relation to social expectations
(source: [9])

3 Socially responsible organization

Referring to the social responsibility and sustainability questions in conjunction with LCA, it is important to describe theoretical basis of CSR. Primary set of guidelines concerning the responsibility of business for the impact on external social environment—stakeholders, and natural environment, is covered by a 2001 *Green Paper: Promoting framework for Corporate Social Responsibility* [6]. Essential matter that is currently discussed and is also reflected in the mentioned *Green Paper*, is an understanding of organizational mission. Older publications (Milton Friedman and others [7]) view organization's mission as a way of providing profits for its shareholders. With development of social awareness, the external environment of the organization is currently viewed in broader terms—including not only direct beneficiaries but all stakeholders, representing variety of entities directly and indirectly linked to the organization's operations [10]. Pursuit of acting in harmony with all stakeholders is understood as an element of long term trust building strategy, which will finally come to fruition in form of profits.

Authors of the *Green Paper* see CSR as a process that gives organizations the ability to manage relationships

with groups of stakeholder having a real impact on its activities. Being socially responsible means not only fulfilling legal expectations, but also going beyond compliance and investing “more” into human capital, the environment, and the relations with stakeholders. The experience with investment in environmentally responsible technologies and business practice suggests that going beyond legal compliance can contribute to a company's competitiveness and result in “win-win” effect [6]: good for business and good for the environment.

Valued theoretician of CSR, Archie B. Carroll, created the first and still valid four-stage CSR model. So called Carrol's pyramid includes subsequent levels of responsibility: from traditional – economic level, through legislative, ethical, and philanthropic [7]. Profit should therefore be only a baseline responsibility of an organization, followed by adherence to law, acting in accordance with ethical values, and finally by fulfilling civic duties. Interesting approach to Carroll's model was formulated by Magdalena Rojek-Nowosielska [9]. According to her interpretation, legal responsibility is currently required by the external environment and ethical responsibility – even though it is not codified – is expressly expected by organization's stakeholders (Fig. 5).

It can be substantiated that practices based on informational noise and intended ambiguity, such as *greenwashing*, refer primarily to two of the areas mentioned earlier legislation and ethics. *Greenwashing* is especially common on the shared area on the border of legislation and non-obligatory actions, considered by the stakeholders as expected. As was mentioned in the introduction, legal level of activity is required, but social expectations and – referring to Carroll's and Rojek-Nowosielska's terms [8], [9] – desires go far beyond it.

For that reason law not always can be a good tool to measure CSR: real CSR starts only where the law is obeyed. For this reason it is important to demonstrate to stakeholders all those elements, which are not covered by the law and may be expressed and confirmed by the accurate, comparable data. Also, for development of knowledge about CSR and sustainability, one of the key challenges is to go beyond theoretical considerations and to start to measure. In the future traditional – so called environmental – LCA may be also supplemented by new modules: Life Cycle Costs (LCC) and Social Life Cycle Assessment (S-LCA), which together cover all areas of sustainability conception and give rise to research on a very large scale.

4 Informational chaos: Oxodegradability

Due to rapid growth of social awareness, depletion of natural resources and evolution of concept of sustainable development, more significance is placed on the so called environmental efficiency of products. This concept encompasses effectiveness of natural resources usage, minimization of waste creation, and pollution on all stages of a product life cycle, while maintaining sufficient quality of products.

Environmental efficiency is one of the key areas of interests for leading world economists. It was studied by – among others – Stiglitz, Sen and Fitoussi in a report, *The Measurement of Economic Performance and Social Progress Revisited* [9]. Currently within the field of effective resource use one can observe an emphasis being placed on promoting substitution of traditional plastic with bioplastics, that is, plastic materials produced from renewable resources and biodegradable plastics. Concept of biodegradable plastics is especially becoming a target for *greenwashing* prac-

tices – both in areas of groundless reporting and even outright and deliberate misinformation.

Biodegradability in simple terms denotes biological decay. This phenomenon results from the fact that microorganisms present in the environment, use some materials as a source of nutrition and in turn digest them – what is important is that this process is devoid of any additional chemical additives [11].

Biodegradation does not apply to traditional polymer plastics such as polyethylene or polypropylene. Those materials were designed to be lasting and resistant to the influence of surrounding biological environment. Even so, market is full of substances (additives) that increase the decay of conventional polymers, causing so called oxodegradation.

Producers speaking the language of science and communicating extraordinary environmental benefits of those additives, advance the *greenwashing* practices exceptionally far.

Oxodegradable additives are not able to convey true biodegradation and what is more, by polluting the composition of plastics they impede waste treatment methods according to sustainable development. This is not the knowledge available for most consumers, but also here helpful can be general product / process / enterprise LCA, taking into account also recycling or waste disposal period and ways.

5 Biodegradability and compostability – testing method

It is also important to mention LCA and generally product/process/enterprise Life Cycle in the context of biodegradable materials and composting. In the instance of mentioned *greenwashing* practice of marketing oxodegradable additives as additives granting biodegradability and/or compostability to traditional plastics, objective assessment method that can prove such claims is defined in EN-13432 standard [12].

Truly biodegradable and compostable can be certified by a number of European certification bodies, such as German DIN Certco (Fig. 6), Belgian Vinçotte (Fig. 7). First two certification bodies are also licensed to grant so called internationally recognized *Seedling Logo* on compostable products (Fig. 8).



Figure 6. DIN Certco compostability label
(source: [10])

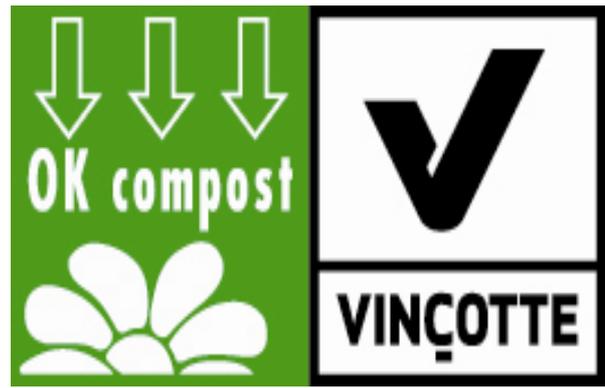


Figure 7. Vincotte compostability label
(source: [10])



compostable

Figure 8. Seedling Logo compostability label
(source: [11])

Those labels, awarded by acknowledged certification bodies on the basis of laboratory testing according to ISO standards are credible confirmations of pro-environmental quality advantage for producers, consumers, authorities at different levels, and all other relevant stakeholders. In the instance of biodegradability and compostability claims, they are one of the best solutions for all organizations deciding to pursue honest green marketing and effectively combat opportunities for *greenwashing*.

6 Life cycle assessment – environmental assessment method

Dissemination of misinformation serving to create environmentally responsible organizational image is one of the more important issues linked to CSR [3]. As mentioned, such practices are contrary to the rule of long term trust building strategy promoted by the *Green Paper* [6]. However they can be used as more of a short term tactic [13]. What is underlined by the authors on *greenwashing*, constant observed increase

of knowledge and sensitivity of public opinion on similar matters, allows to easily identify scientifically unsupported environmental declarations [3].

Abuses of some of the producers can also translate on more general trend of lost confidence of customers and in effect to limiting expectations of organization's responsibilities to the lowest economic level, which will have a negative impact on the social growth. It is therefore very important to search for more objective methods of environmental impact assessment of organizations on its environment. One of the commonly used method is called LCA, along with so called Carbon Footprint indicator calculation.

In the instance of LCA, life cycle has got a different form than in classical examples. In traditional economic sciences, life cycle of organization or product refers to volume of sales in a given time period. In the instance of LCA from the environmental point of view, it is a study of all material inputs and processes needed to create, distribute, use, and dispose of the product, service, or even entire organization.



Figure 9. LCA seen as a loop of improvement of environmental damages on human health, ecosystem quality, and use of resources

This study leads to the phase of interpretation that can be used to optimize actions within generated environmental impacts and damages – most commonly in three main categories – human health, eco system quality, and the use of resources (Fig. 9).

LCA is an objective method of assessing such issues as the use of energy, environmental damages, impacts linked to product, processes, or stages of organization's operations within full value chain. LCA gives possibility to calculate detailed and cumulated impact on environment and in the form of environmental declarations provides a proof of conducting effective and sustainable environmental and social communication to the organization itself and to all its direct and indirect stakeholders.

LCA can be perceived on three levels as [14]:

- assessment method of environmental impacts and effects,
- in the instance of specific use, as a tool for this assessment,
- universal philosophy of thinking about an organization in categories of damages and costs that the organization generates; in this sense LCA becomes a full optimization loop, similar in concept to Deming Cycle or Six Sigma.

LCA is an ISO standardized method – LCA concept is described in ISO 14040 [14] standard, and specific

aspects in the following standards from the series 14044 [15], 14047 [16], and 14049 [17].

7 Carbon footprint – analysis

LCA can also be used to calculate the sum of greenhouse gases emissions generated directly and indirectly within a full life cycle of a given subject matter. This is commonly called a Carbon Footprint (CFP) or a Carbon Profile [19]. CFP calculations are promoted by an organization supporting sustainable and low emission economy called Carbon Trust. The company offers a special *carbon reduction label* (Fig. 10.) This label can be especially helpful in green marketing as it indicates a total value of greenhouse gases emission (shown as a carbon dioxide equivalent mass) through all processes in life cycle and value chain of assessed product, service, or organization. Similar to the compostability certification, placing a carbon reduction label on the packaging of the product, portrays true and confirmed numerical data of the products' greenhouse gases emissions and helps the consumers in making comparisons and informed decisions, countering dishonest competition.

An example of *carbon footprint*, comparative analysis of four types of products, utilizing LCA was performed in COBRO - Polish Packaging Research and Development Centre.

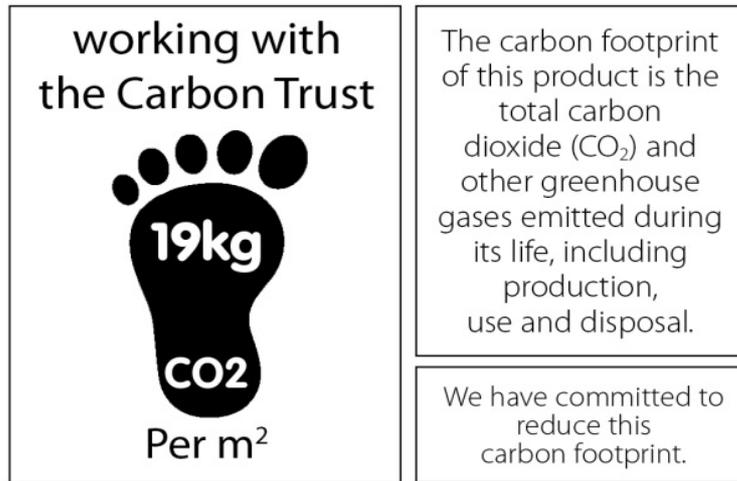


Figure 10. Example of Carbon Reduction Label informing about cooperation with Carbon Trust and displaying greenhouse gases emissions (source: [11])

Four products were assessed for their greenhouse gases emissions – packaging trays of same volume and shape produced from:

- Polyethylene terephthalate (PET) – traditional fossil based plastic,
- Polypropylene (PP) – traditional fossil based plastic,
- Polyethylene terephthalate (PET) with 30 percent content of recycled polyethylene terephthalate (rPET) – traditional fossil based plastic,
- Polylactic acid (PLA) – bio-based plastic made primarily from corn-starch [19].

The first two types belong to the so called conventional plastic group. Those plastics are not biodegradable nor compostable and are considered to be harmful to the environment in the long term by the general public. This is why currently, the industry seeks for more environmentally sustainable alternatives to those materials, which in certain cases, such as in the example of oxo-degradable additives, can lead to the phenomena of *greenwashing* and speaking the language of science with the objective to influence the consumer. The third type of tested packaging is produced from the same conventional plastic as the first one – PET, however in this example, 70% of this material is made from the virgin material and 30% comes from recycling. The producer of this material, took certain real actions that limit the environmental damages during the production process. The last type of material is a fully

biodegradable material, which is made entirely from renewable resources, in this case, corn-starch.

Carbon footprint of those products was calculated using LCA software Sima Pro 7.3 by Pré Consultants, using the Intergovernmental Panel on Climate Change (IPCC) Global Warming Potential method. Final numerical results of the study (expressed as kilograms of carbon dioxide equivalent per used functional unit – in this instance 1000 packages of each type of packaging) indicating the total sum of all greenhouse gases directly and indirectly emitted by the assessed product can be found in Table 1.

Obtained results, as expected, show that the highest *carbon footprint* indicator belongs to packaging from traditional plastic – Polyethylene terephthalate (PET). In the instance of recycled PET – the same plastic, but with 30 percent content of recovered material, the *carbon footprint* indicator is 0.018 kg lower, per one package (more than 18 kg carbon dioxide equivalent for 1000 packages). *Carbon footprint* of other conventional plastic–PP–is on a similar level to PET. Polylactic acid (PLA) however, which in a functional sense can be considered as a more sustainable substitute of PET, has got a *carbon footprint* of 60% of this for the PET.

This type of numerical data obtained by using standardized methodology, along with clear indication of proportions between results for different products and their possible substitutes, should represent a basis for apt environmental assessment and general management of organization's processes.

Table 1. *Carbon footprint* indicator results for four tested plastics (source: [19])

Carbon footprint indicator	Unit	Packaging			
		PP	PET	PET with recycled PET content (rPET)	PLA
Total, including:	[kg CO ₂ equivalent for 1000 packages]	71.54	90.72	72.56	57.83
CO ₂ from fossil resources		63.35	81.66	65.70	88.25
CH ₄ from fossil resources		7.83	8.39	6.27	4.45
N ₂ O		0.22	0.42	0.37	7.73
Remaining (photosynthesis CO ₂ included)		0.13	0.25	0.21	-42.60*

* negative value signifies CO₂ absorbed from the atmosphere in the photosynthesis process

It allows to avoid a lack of precision and in extreme cases, abuses in determining pro-environmental actions of the organization, on the other hand it can also be used as a method of preventing image crises of organizations in the field of environment and sustainability.

What should be emphasized, concept of Carbon Footprint calculation, can be also used as a general basis for further CSR and sustain development measurement using LCA principles. Such research has been already started by the authors as a part of doctoral thesis prepared in the Faculty of Management of Warsaw University of Technology in cooperation with COBRO-Packaging Research Institute, under the direction of Professor Stanisław Tkaczyk. LCA method of inputs and outputs analysis and professional LCA software Sima Pro can be useful also for assessment of other parameters relevant to the concept of CSR.

8 Conclusions

In the light of presented literature review, LCA principles, and provided examples of results, it seems justified to state, that LCA can be seen as both: promising attempt to introduce specific rules of the CSR or sustainability measurement for the needs of science and the market and as successful way of countering unreliable environmental marketing, known as *greenwashing*—adopted in different forms: from communication errors, through creating information noise, to finally

obvious malpractices – is development of more objective methods of environmental assessment of organization. Those methods should allow to define suitable functional units as a basis of assessment, and show numerical and quantitative values of generated environmental damages. Conducted assessment should also be founded on commonly accepted standards – such as ISO standards. An example of such environmental assessment method is LCA – used for more than 40 years as a method or tool of eco balance, and increasingly viewed as loop of constant organizational improvement. Also future application of this method to recent tasks, especially in area of management sciences and CSR, is promising.

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DIRECTIONS OF CHANGES IN ORGANIZATIONAL STRUCTURES OF SME - RESULTS OF EMPIRICAL RESEARCH

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Abstract: The article presents results of empirical research concerning the directions of changes in organizational structures of SME which have occurred during the last few years. The research was carried out in a group of 380 enterprises running their businesses in Poland. The organizational structure generally described in respect of parameters such as centralization, formalization, standardization and configuration. The main part of this article is dedicated to changes that have occurred in organizational structures of SME.

Keywords: organizational structure, change, centralization, formalization, standardization, configuration.

1 Introduction

Organizational structure is a system of certain elements and their relations which should make it possible to attain goals of an enterprise. Forming organizational structure and the organizational structure itself is very important for correct functioning of the entire enterprise. The role of the organizational structure is most of all to coordinate and arrange the functioning of an enterprise and to enable attainment of planned goals.

It should be noted that the concept of organizational structure is still not clearly defined in the literature. There are differences in the perception of the organizational structure. It arises from many factors, but it is worth mentioning such factors as the complex nature of the organizational structure and a difficulty in the objective of extracting the entire management system. In addition, the diversity in defining the organizational structure is affected by the views and attitude of the researcher. However, some definitions of organizational structure have some points in common. It can therefore be divided into three main types of definitions, based on the elements and/or the relationship between the elements of the organizational structure. The first type of definitions are those that are focusing mainly on the elements of the organizational structure (R.W. Griffin [3]; R. Krupski [14]). The second type of definitions are those that emphasize relationships between different elements of the organizational structure (J. Zieleniewski [15]; W. Kieżun [6]; Strategor [13]; A. Schaff [11]; A. Nalepka [8]). In the third type, definition elements of the organizational structure and the relationships between them are placed on an equal footing (A. Zakrzewska-Bielawska [9]). There are also some definitions which are difficult to classify into the

above three types. These definitions emphasize patterns or rules of action in the enterprise in the description of the organizational structure (H. Steinmann, G. Schreyogg [12]; M. Hopej, R. Kamiński [4]). Among the different definitions, better reflect the essence of the organizational structure that which emphasize the relationships and connections between the elements of the structure or equate elements and connections between them. The advantage of this perception of the organizational structure is that it facilitates the transition to the issue of improving the organizational structure. The problem of improving the organizational structure focuses on change of the relationship and arrangement of the elements of the organizational structure to ensure greater effectiveness.

Organizational structures have been changing along with changes occurring in enterprises. If we look at the development of industry, certain stages or directions of enterprises development can be distinguished. These directions of development were accompanied by changes within enterprises. Sometimes these changes were introduced in advance to maintain high level of enterprise operation efficiency, and sometimes the changes were forced by both internal and external factors. It can be stated however that organizational structures were evolving, just like enterprise management.

Organizational structures of enterprises have evolved from simple solutions towards more complex and sophisticated systems. Changes that have occurred in the structures of economic entities have been caused by several factors, such as strategy, type of environment, applied technology, and others. Numerous researches link the evolution of organizational structures with evolution or sometimes even revolution that has

occurred in their environments. It can be said that changes in organizational structures of enterprises followed changes in the environment. Technological development, open borders, enhanced hyper competition, “californization of need” – all these phenomena have caused changes of enterprises, their strategies, and structures.

Evolution of organizational structures and introduction of new structural solutions is also related to development of management sciences. Classical organizational structures originate from the concept of bureaucracy and are related to organization of work applied in the 19th and 20th centuries. Classical organizational structures are hierarchical structures distinguished in respect of organizational relations. Modern organizational structures started to emerge in 1990s, when such management concepts were developed as *lean management*, *outsourcing*, *reengineering*, *knowledge management*, *process management*, and others. Now, such concepts like *insourcing*, *cloud computing*, and *agile enterprise* affect the global business [2]. All these concepts significantly modify enterprises’ way of operation and, consequently, require adjustment of organizational structures. The opportunity to introduce structural changes is also created, or even enforced by the development of information technology. However, despite emergence of many modern structural solutions, classical organizational structures are still commonly applied in enterprises. They are a kind of “basis” on which additional structural solutions are introduced which are conducive to effective operation.

The themes of changes of organizational structures are particularly interesting in the research concerning the Polish enterprises. They did not have as much time for evolution as American or European companies. Changes in the structures of Polish enterprises were introduced suddenly, as a kind of response to the changes in their general conditions of functioning. Polish enterprises, both large and small, started to implement solutions applied commonly abroad. It seems therefore interesting to analyze how organizational structures of Polish enterprises are currently being shaped, and also whether they have changed during the last years of crisis and to what extent. The aim of the article is to answer these questions. Directions of changes in the organizational structures of SME operating in Poland were established on the basis of a quantity research. The author assumed not only that the organizational structures of SME are flexible,

but also recently increased their flexibility. In the following parts of the article, will be presented methodology of the research, form of the organizational structure of SME, and changes in the organizational structures of SME. At the end the main conclusions of the research and directions for further research will be outlined.

2 Methodology of the research on the changes of organizational structures of SME

Analysis of changes in the organizational structures of enterprises from the SME sector was one of the elements of a scientific project aimed at identification of organizational structures of this group of enterprises, carried out in 2012–2013 under the direction of W. Jakubowska [5].

Changes in the organizational structures of SME were analyzed using a sample of 380 companies from the SME sector. The research was carried out using the Computer Assisted Telephonic Interview (CATI) method, which made it possible to analyze a large group of enterprises. The CATI research was ordered to the “Indicator. Centrum Badań Marketingowych” company. The research sample was drawn out from the *Hoppenstedt & Bonnier* base as of the end of 2010, comprising information on business entities operating across Poland. The sample was an equinumerous stratified sample. The research was carried out in three strata, distinguished on the basis of the number of employees working in an enterprise, which corresponded with three groups of enterprises: micro-, small, and medium-sized ones. Percentage shares of particular enterprise groups in the entire research sample are presented in Fig. 1.

Other parameters describing the research sample are: age of an enterprise, industry sector, legal and organizational form, and origin of capital. Enterprises under research differed in respect of their year of establishment. A majority of them, i.e. 66.3%, were established during the transformation period, which is between 1989 and 2004. About 19.5% accounted for enterprises created before the transformation period, while 14.2% were those established after Poland’s joining the European Union. Taking the industry sector into account, production enterprises accounted for 39.7%, service providing enterprises were 33.4%, trade enterprises were 20.5%, and enterprises of the administration sector were 6.3%.

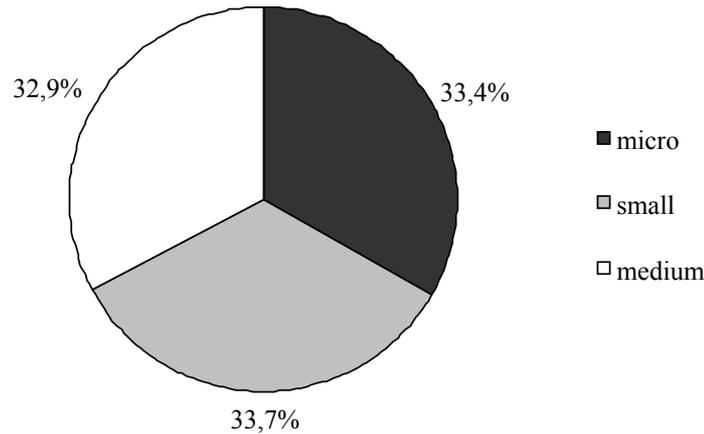


Figure 1. Description of the research sample in respect of number of enterprise employees

In respect of the organizational and legal form, limited liability companies were prevailing (63.9%). Due to the origin of the capital dominated companies with national capital (72.4%).

Analysis of changes in the organizational structure of SME was preceded by statistic evaluation of various aspects of organizational structure. Parameters such as centralization, formalization, standardization, and configuration were considered. Each parameter was evaluated according to a five-point scale, where 1 meant a very low level and 5 meant a very high level. For the configuration parameter, a question about the exact number of levels was asked.

Analysis of the parameters characterizing the organizational structure is a multidimensional approach which allows for a better description of the organizational structure than mapping it to one of the types shown in the literature. This approach allows identifying the characteristics that can be associated with the flexibility and positive impact on the results achieved by the enterprise.

Because of a multidimensional approach to the analysis of organizational structure, analysis of directions of changes was also carried out from the perspective of changes in various dimensions of organizational structure. They were examined using questions about the direction of changes that have occurred during the last few years in an enterprise.

The research therefore consisted in subjective evaluation of changes in the organizational structure of respondents, who were mainly the owners and managers of enterprises. They were asked about basic dimensions of the organizational structure, which are: centralization, formalization, standardization, as well as changes

in configuration, i.e. the number of levels and organizational units. Changes in each dimension of the organizational structure were evaluated according to three-point scale, where 1 meant lowering the level of the analyzed parameter of the organizational structure, 2 meant no changes in the level of the analyzed parameter of the organizational structure and 3 meant raising the level of the analyzed parameter of the organizational structure. Directions of changes were identified both for the entire research sample and from the perspective of a particular category of enterprises.

3 Form of the organizational structure of SME

Discussing directions of changes in the organizational structure of SME requires outlining the shape of organizational structure that emerged on the basis of the research. However, since it is not the main subject of this article, it will only be discussed in short. Only facts that are significant for further deduction will be presented.

Organizational structure of an enterprise can be described according to various dimensions. The most common approach is that of the Aston University researchers [10] who distinguished five basic parameters of the organizational structure, which are: specialization, standardization, formalization, centralization, and configuration. This article identifies the following parameters of the organizational structure: centralization, formalization, standardization, and configuration.

The way these organizational structure parameters of the analyzed enterprises were formed is discussed as follows.

First, the centralization dimension was analyzed as a part of the research on SME organizational structures. Centralization consists in taking away decision rights and allocating them to higher level managers. It turned out that among the 380 analyzed enterprises, as much as 71.8% declared high and very high level of centralization, 23.7% of the enterprises under research reported medium level of decision centralization, and very few (4.5%) reported low or very low level of centralization.

The level of formalization of enterprises under research was also relatively high. Formalization sets company patterns of behavior and is reflected by the number of documents, their level of detail, and strictness of their use. High and very high level of formalization was declared by 41.1% of enterprises, while 40.8% of them declared medium level of formalization. It can be therefore stated that over 80% of enterprises declare medium or higher level of formalization.

The level of standardization in the analyzed enterprises was also high. Standardization consists of unification of the enterprise's way of functioning. It therefore means limiting discretion of action, but also ensures unified ways and rules of behavior. About 61.1% of enterprises declared that their level of standardization of actions was high or very high, while 33.4% of enterprises described their level of standardization as medium. Again, if we aggregate results, it turns out that over 90% of enterprises describe their standardization level as medium or more than medium.

The last analyzed dimension of organizational structure is configuration. The configuration dimension concerns the structure of an enterprise in respect of its system and relations among particular units, departments, etc. Configuration is closely related to the hierarchy, and thus this dimension is often directly called "the hierarchy". The research proved that enterprises from the SME sector are characterized by a medium level of complexity. Average number of levels in the analyzed sample was 3.42, and the median was 3. As much as 46% of enterprises declared having three organizational levels, and 37% of enterprises reported having more than 3 organizational levels. In respect of the number of levels they can be therefore classified more as leptokurtic than platykurtic.

Summing up, we can state that small and medium-sized enterprises have rather mechanistic organizational structure. It was proved that organizational structures

of the analyzed enterprises had a high level of formalization and standardization of actions, centralization of decisions, and relatively high number of organizational levels.

4 Changes in the organizational structures of SME

The author wanted to learn whether the above description of organizational structures is the effect of changes that have occurred in the organizational structures of the analyzed enterprises in the recent years. The aim of the research was therefore to answer the question about the way some organizational structure dimensions in the analyzed enterprises have changed in the last years. Directions of changes in the selected organizational structure dimensions are presented below for the entire group of SME, broken into categories according to the number of their employees.

Changes in the level of centralization of SME were analyzed first. The analyzed enterprises had a high level of centralization and it turns out that this dimension has not changed during the last few years (58% of enterprises reported so). What is more, as much as 24% of enterprises declared that their level of centralization had grown during the last years (Fig. 2).

Interestingly, definitely the largest number of small enterprises declared lack of changes in respect of centralization level (63.3%). About 17.2–18.4% of entities in each group of enterprises declared lowered level of centralization. The largest number of entities in the group of medium-sized enterprises declared increasing the level of centralization (28%). Detailed structure of answers concerning the changes in the centralization level broken into categories is presented in Fig. 3.

Another dimension analyzed in respect of changes that have occurred was the level of formalization. The research showed that the level of formalization of small and medium-sized enterprises is high, so the respondents were asked about the directions of changes in the level of enterprise formalization. Most respondents consider that the level of formalization has not changed during the last few years. However, among those who consider that the level of enterprise formalization has changed, as much as 25% of respondents report that it has grown (Fig. 4).

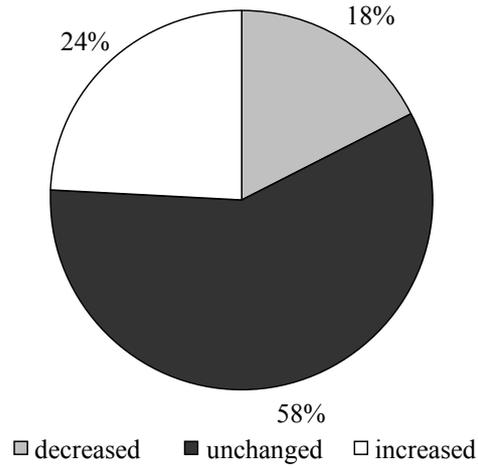


Figure 2. Changes in the level of centralization of SME

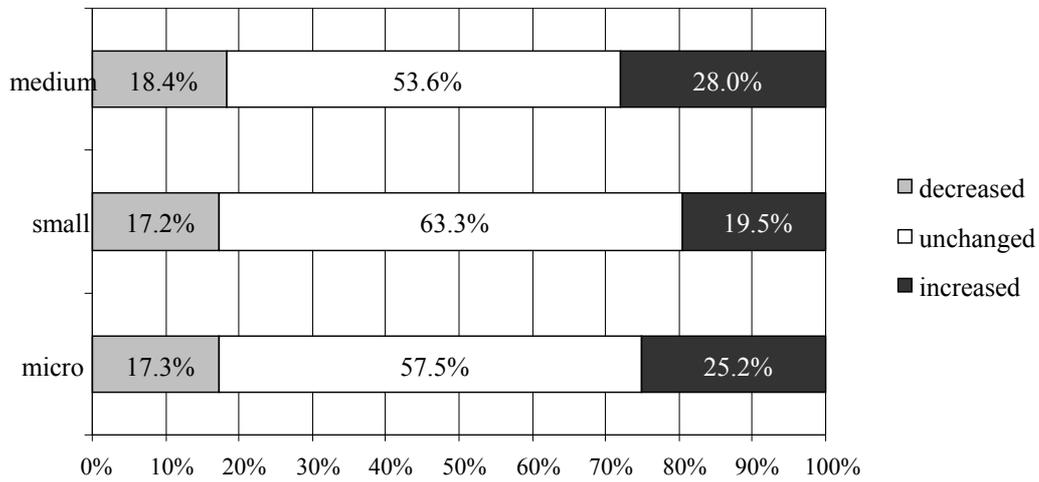


Figure 3. Changes in the level of centralization according to categories of SME

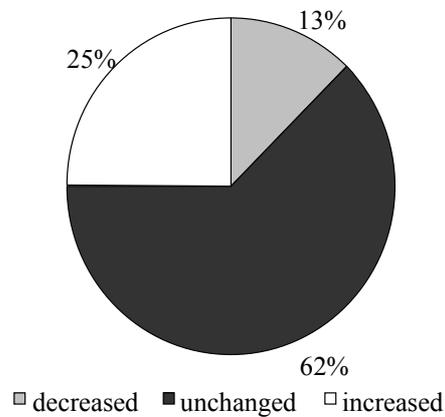


Figure 4. Changes in the level of formalization of SME

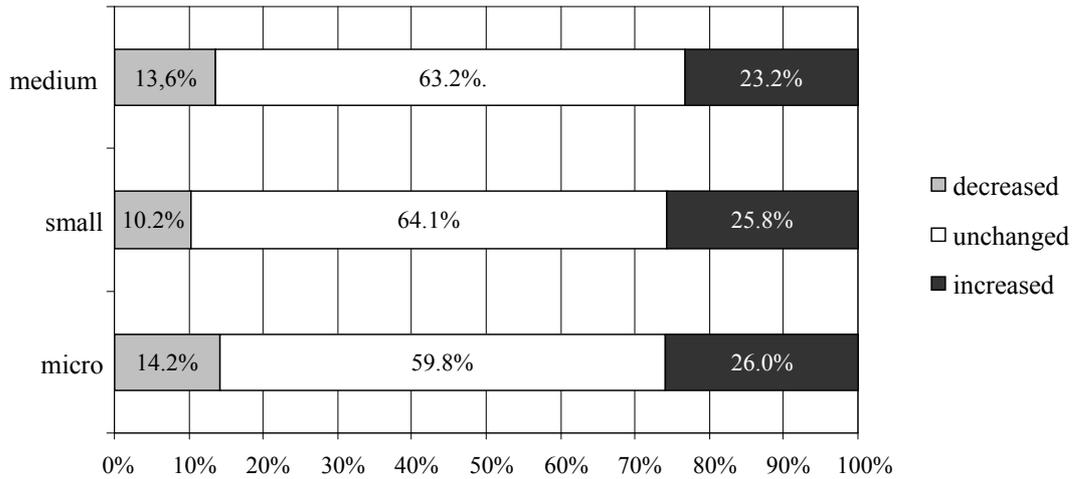


Figure 5. Changes in the level of formalization according to categories of SME

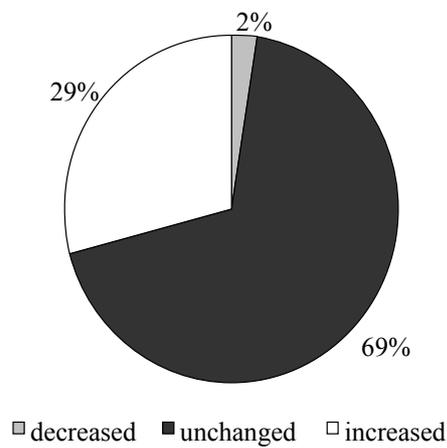


Figure 6. Changes in the level of standardization of SME

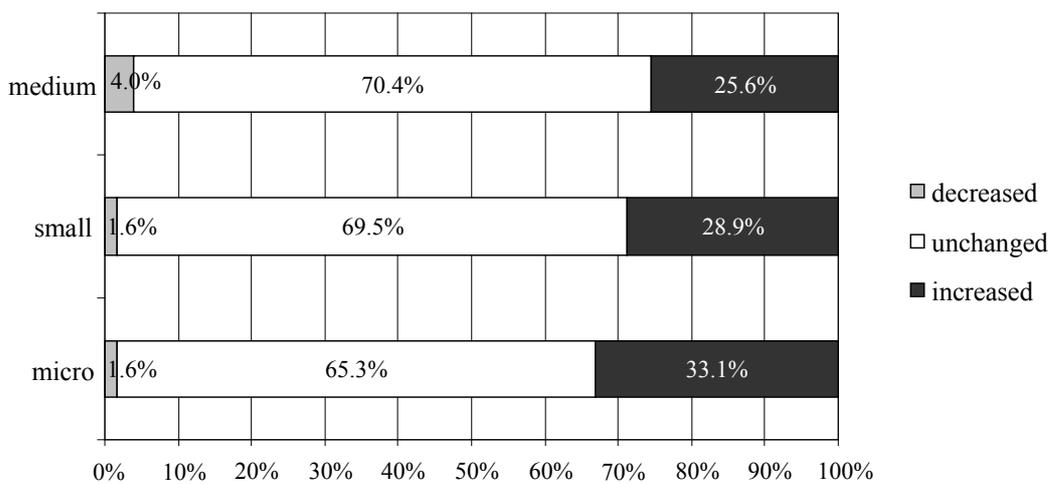


Figure 7. Changes in the level of standardization according to categories of SME

Similar results concerning the perception of changes in the level of enterprise formalization were observed in each of the research groups. Most of them declared lack of changes in the formalization level, and if any changes were recorded, these were directed towards raising the formalization level of an enterprise. Detailed structure of answers concerning the changes in the formalization level broken into categories is presented in Fig. 5.

Another analyzed parameter was the standardization of actions. Most respondents (69%) consider that the level of standardization has not changed during the last few years. Among enterprises that have recorded changes in the standardization level as much as 29%

indicated changes towards enhanced standardization (Fig. 6).

The analysis of changes in the standardization level broken into the groups of enterprises also showed that it has not been changed. About 65-70% of enterprises answered so. However, if any changes have occurred, these have been changes towards enhancement of standardization of actions. Interestingly, it was true mainly for micro-sized enterprises. It was observed that the bigger the size of enterprises, the smaller number of them declared raising the level of standardization during the last few years. Detailed structure of answers concerning the changes in the standardization level broken into categories is presented in Fig. 7.

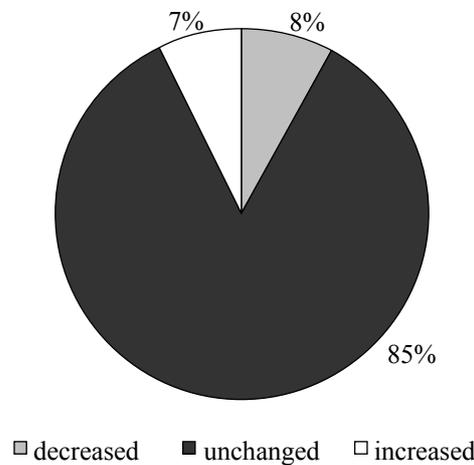


Figure 8. Changes in the number of organizational levels of SME

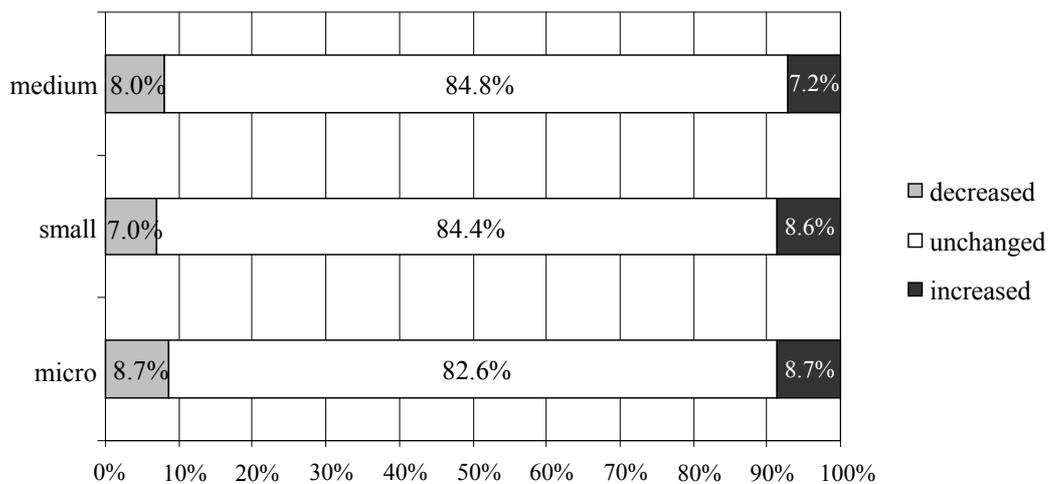


Figure 9. Changes in the number of organizational levels broken into categories of SME

The configuration dimension was also analyzed in addition to the level of centralization, formalization, and standardization. As a part of the research concerning the changes in the organizational structure a question about the change in the number of organizational levels and units in enterprises was asked. Analysis of changes in the number of organizational levels showed that it was not changed in 85% of enterprises. However, among enterprises introducing changes a similar number of those which increased the number of organizational levels was reported to those which decreased the number of organizational levels (Fig. 8).

The division of SME into categories led to conclusions similar to those stemming from the analysis of the entire group. The enterprises were not eager to add another organisational level to their structures. Detailed structure of answers concerning the changes in the

number of organizational levels broken into SME categories is presented in Fig. 9.

An analysis of changes in the number of organizational units showed that enterprises more willingly introduced changes in this scope. Over 40% of respondents declared changing the number of organizational units. Similar groups have increased and decreased the number of organizational units (Fig. 10).

After dividing the enterprises into groups on the basis of the number of their employees, it turned out that the biggest numbers of changes were introduced by medium-sized and small enterprises. It was also observed that in the group of small enterprises, definitely more of them indicated growth of number of organizational units. Detailed structure of answers concerning the changes in the number of organizational units broken into SME categories is presented in Fig. 11.

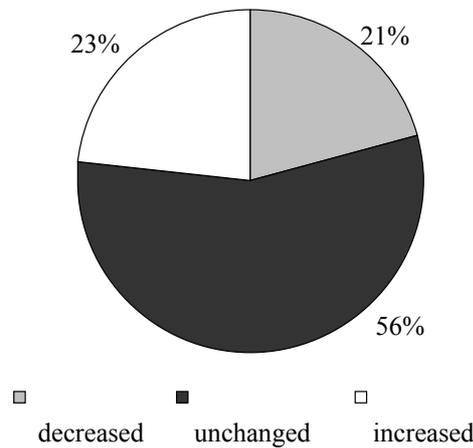


Figure 10. Changes in the number of organizational units of SME

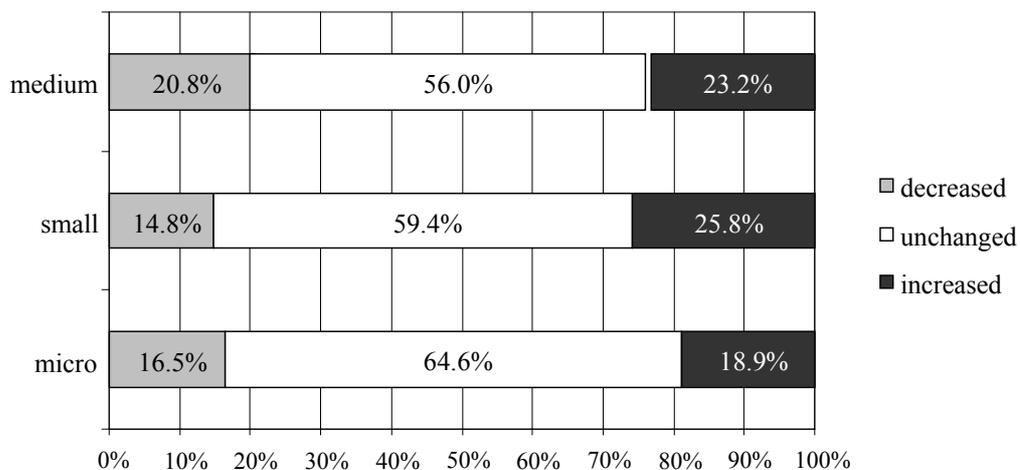


Figure 11. Changes in the number of organizational units broken into categories of SME

Table 1. Directions of changes in parameters of organizational structure of SME enterprises in percentage terms

Structure parameters	Description of parameter	Directions of changes in recent years	
Centralization	High level	↑ (growth)	24%
		– (no changes)	58%
		↓ (drop)	18%
Formalization	High level	↑ (growth)	25%
		– (no changes)	62%
		↓ (drop)	13%
Standardization	High level	↑ (growth)	29%
		– (no changes)	69%
		↓ (drop)	2%
Configuration	Medium and large number of organizational levels	↑ (growth)	7%
		– (no changes)	85%
		↓ (drop)	8%

5 Recapitulation

The author was curious whether and what changes were introduced by enterprises in their organizational structures. The research showed a lack of significant changes in the organizational structures of micro-, small, and medium-sized enterprises during recent years. Additionally, no significant differences in particular subgroups of enterprises were observed in comparison to the entire group under research. Detailed specification of the analyzed parameters of the organizational structure with their general description and recorded changes in their level is presented in Table 1.

Most enterprises have not introduced significant changes in respect of centralization, standardization, or formalization, as well as in respect of the number of organizational units and levels. The enterprises had a high level of formalization and standardization of actions, as well as centralization of decisions. They also covered structures with a relatively developed number of organizational levels.

These dimensions also have not changed during recent years. A prevailing number of enterprises have not indicated any changes in these parameters. Among the enterprises which reported changes in the organiza-

tional structure parameters, a vast majority indicated growth of the parameters, except the parameter of configuration understood as a number of organizational levels.

The structure of the investigated enterprises was classified as mechanistic. In addition, the changes which take place in the organizational structures have stiffening of the organization. The enterprises became even less flexible. The lack of changes of organizational structures is particularly interesting in the context of crisis, because the crisis is a symptom of a turbulent environment. With instability of environment is connected concept of the flexible organizational structures. It is understood that in such conditions, the companies should have a flexible organizational structure or make changes to it in the direction of their flexibilizing.

This conclusion was confirmed by numerous studies carried out, inter alia, by T. Burns and G.M. Stalker [1] and P. Lawrence and J. Lorsch [7].

They showed that companies operating in unpredictable surroundings and having less formalized structure were gaining better economic performance. However, completely different results were obtained in the study of SME.

It turned out that despite worse a economic situation less than half of the enterprises had implemented changes in their organizations.

Simultaneously, changes consisting in reducing organizational units or the number of levels were reported in less than one-fifth of the analyzed enterprises. It is possible that the analyzed enterprises managed to do well in the crisis period or maybe they introduced changes in the organizational structure right after the beginning of the crisis, adapting the structure to the external conditions.

The author supports conclusions stemming from other researches, according to which enterprises apply proven, classic structural solutions and only when a specific need arises, they implement smaller modern solutions. It is also possible that the few-years period about which the enterprises were asked is not enough to introduce changes in organizational structures. Their evolution takes more time or is not clearly recorded by the respondents. It can be presumed that the evolution of organizational structures of small and medium-sized enterprises is very slow.

Described studies should be deepened in qualitative research because of the complexity of organizational structures. In addition, it would be worthwhile to repeat this study using the method of in-depth interviews with members of management, as well as on another sample of enterprises. Comparison of the results would be very interesting.

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