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Foundations of Management

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 synergy between two parallel trends in managerial sciences: social and economical. Social trend originates from economic universities and academies and the engineering trend comes from factories and technical universities.

Three of the great representatives of the engineering trend in managerial sciences on the break of the XIX and XX century, all created the universal foundations of the management sciences: American Frederic W. Taylor (1856-1915) – developer of high speed steel technology and the founder of the technical and physiological trend in scientific management; Frenchman Henri Fayol (1841-1925), the author of basics of management and the division and concentration of work as well as the Pole Karol Adamiecki (1866-1933) graduate of the Saint Petersburg Polytechnic University and the professor of Warsaw University of Technology, creator of the timescale system elements scheduling theory and diagrammatic method as well as the basics of the division of work and specialization.

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 – all 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.

Through publishing the Foundation of Management we would like 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 will adapt to current trends because of wanting to answer to the changing economic and social challenges in the integrating Europe and World.

Tadeusz Krupa

CONTENTS

CONCEPTIONS FOR FINANCING A UNIVERSAL, OPEN, REPOSITORY HOSTING AND COMMUNICATION PLATFORM FOR WEB-BASED KNOWLEDGE RESOURCES

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Abstract: The subject of this paper are alternative funding schemes for a planned universal, open, repository hosting and communication platform for web-based knowledge resources for science, education and an open knowledge society. An attempt is made to estimate the amount of funding needed by analysing the costs of procuring content from foreign and domestic sources, the digitization of library resources, capital expenditures and operating expenses of the institution that will manage the SYNAT platform. Assuming that access to knowledge resources will be free of charge for specified groups or all users, the potential revenue generated by the platform is defined – mainly: directly or indirectly from the national budget and supplementally from private sources. The possible organizational and legal forms of the institution administering the SYNAT platform – public and private sector entities – are reviewed in terms of the certainty and elasticity of funding by the national budget as well as other sources, ensuring the on-going operation of the scientific and technical information system.

Key words: SYNAT platform, costs, revenue, public (national budget) and private sources of funding, organizational-legal form of the institution administering the platform.

1   Introduction[1]

The SYNAT project will result in the creation of a universal, open, repository hosting and communication platform for web-based knowledge resources for science, education and an open knowledge society – the technical and organizational basis for the National Information System for Science and Technology (Polish acronym: KSINT). The SYNAT platform is intended to contribute to the growth of Poland's intellectual capital, thereby helping to increase our economy's competitiveness. This platform is expected to perform a range of functions, primarily:

- integrating existing knowledge resources by making them accessible from a single place according to the same standards (on the Infoma scientific communication portal),

- managing the purchase of content licences from commercial providers,

- maintaining knowledge resources on its own servers (its own resources as well as the resources of external users interested in using hosting services),

- administering a portal that provides access to knowledge in the Open Access formula,

- technical maintenance of servers,

- offering advanced services for a fee.

In formulating the funding scheme for a universal, open, repository hosting and communication platform for web-based knowledge resources, two issues need to be resolved, namely:

1) funding of initial capital expenditures (furnishing the necessary assets – equipment, patents, licences etc.),

2) funding of operations.

The first case concerns assets that constitute someone's property, thus their owner's role is to create them and reproduce them for the sake of attaining specified goals. The solution to this problem is tied to the choice of organizational-legal form of the entity, which identifies the owner as well as the scope of this entity's rights and duties.

The second issue is universal in character, independent of the entity's organizational-legal form, and boils down to specifying the sources of revenue necessary to cover operating expenses and, in the case of self-financing organizations, ensuring funds needed for development. Regardless of whether the platform is a commercial or non-profit venture, the starting point must be identification of the expenses it will incur.

In this paper the business model recommended for the SYNAT platform is a centralized coordination system [7] – a comprehensive platform that integrates existing domestic repositories and, as needed, creates new ones, on an Open Access basis. It appears necessary, however, to establish and maintain a central repository that gathers the results of publicly funded research in Poland, which is a missing link in open access to domestic knowledge resources.

2   SYNAT platform operating expenses

The expenses of the SYNAT platform will include:
- costs of buying content licences from domestic and foreign publishers,
- costs of digitizing existing resources,
- current operating expenses of the institution administering the platform,
- costs of maintaining institutional and thematic repositories that function separately (do not use the hosting services of the institution administering the platform),
- costs of meta-data preparation.

3   Content procurement costs

In the matter of content procurement costs we should refer to the practices of Polish repositories in obtaining foreign sources of knowledge. The Ministry of Science and Higher Education (MNiSW) awarded grants of 156.7 million zł, 148.9 million zł and 144 million zł, respectively, during the years 2010-2012 [18] to cover the costs of maintaining and expanding the Virtual Library of Science – i.e. the purchase of domestic academic licences granting access to renowned foreign periodicals (a portion of these acquisitions did not include archiving rights). MNiSW subsidizes up to 50% of consortium licensing costs. It's difficult to estimate the costs that would be incurred in buying the deep resources of publishers, as they will depend

on how great the demand is for access to electronic sources of knowledge made available on a commercial basis as well as the transaction prices, which are often considerably lower than listed prices because various discounts apply to them[2]. Access costs to domestic knowledge resources remains an open question. Also unknown are the expenditures to be incurred for non-exclusive licences, which enable all users of the platform to access scientific content.

Likewise it's difficult to estimate the costs of digitizing Polish library resources. According to the Government's "Kultura+" programme [2] adopted in 2010, the costs of implementing the "Digitization priority" over the period 2011-15 are estimated to come to 141.25 million zł, of which 120 million zł is to be covered by the national budget. The purpose of this priority is to support the digitization of cultural resources by means of buying digitization equipment, conducting the digitization process and electronically disseminating the digitized collections, including library materials, museum exhibits, relics, archives and audiovisual materials. But will these expenditures suffice to digitize all resources? The programme covers cultural resources, but scientific and technical resources, for instance, will still be left to digitize. The costs of meta-data preparation are also unknown.

In respect to content from domestic resources, we recommend open mandates, understood as the obligation to publish the results of publicly financed research in Open Access periodicals or deposit them in open repositories. "The Open Access mandate is an act issued by an authorized body of the given institution by virtue of which persons remaining in a specified relationship with this institution shall be obliged to ensure open access to the scientific content which they authored."[3]

Making auto-archiving compulsory is the most effective method for systematically procuring repository resources. Studies have shown that if auto-archiving is a requirement, 80% of researchers will submit their works to archives [16]. The idea of forcing publication in an open repository is not new, as many institutions funding research follow this practice.

The European Commission, under the VII Framework Programme of Science, has undertaken a pilot study

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[2] An extensive review of the world electronic resources market is contained in a report conducted under the SYNAT research task [9].

[3] I cite p. 143 for [6].

on scientific publications that was prepared under the Programme. The Commission recommended that all research work from the Programme be made accessible in the Internet within 6-12 months [4]. Pursuant to the rules governing grants under 7FP, researchers who use EU funds in the fields of health care, power engineering, environmental protection, information technology and communications, research infrastructure, social sciences, humanities and public surveys are obliged to submit – at the same time they submit for publication – the full contents of their peer-reviewed publications to a special, freely and generally accessible virtual library (the repository of their institution – if one is available – or the OpenAIRE Orphan Repository), where they will be made accessible immediately or with a certain time lag, without temporal or geographic limitations. This applies to about 20% of all projects financed by 7FP. Researchers in other fields of science may also decide to make their work accessible according to the same rules.

In the latter part of 2011, the Ministry of Science of Great Britain signalled its intention to force the publication of the results of publicly funded research in the Open Access model. The move to this model will take place provided that peer review is maintained and publication in Open Access is compulsory. One of the options guaranteeing the cost effectiveness of this process is to move from a model whereby periodicals are paid for by university libraries to a model under which researchers themselves pay for publishing. In this case, however, the researchers would receive grants to enable them to do so [5].

The rule in the USA is that scientific works based on research financed by the National Institutes of Health must be deposited in the PubMed Central data base immediately after they are accepted for publication, and made accessible no later than 12 months after publication. There, too, a discussion is under way on a regulation proposed by the government that would reduce the interval from publication to Open Access to 6 months[4] (it would apply to all scientific institutions that receive annual outlays in excess of 100 million USD). Ukraine enacted a law in 2007 that requires Open Access publication of all publicly financed research results; Lithuania has enacted a similar law. **[5]**

Open mandates should be adopted by the institutions that finance research in Poland: National Science Centre (NCN), National Research and Development Centre (NCBiR), institutions of higher learning, Polish Academy of Sciences (PAN), scientific institutes whose employees conduct publicly financed research within their statute activity and other institutions that dispose of public funds for research grants. Private sponsors of research can be encouraged to adopt Open Access mandates by awarding them tax preferences or priority status when they apply for public funding.

This method of providing the SYNAT platform scientific and technical materials in digital format fits the support-worthy new scientific communication system, a scheme formulated by the Interdisciplinary Mathematical and Computer Modelling Centre at the University of Warsaw (ICM UW). All results of scientific and research work funded by institutions that have adopted the Open Access mandate are to be deposited in open repositories – immediately in the case of the so-called Gold Path (scientific publications in peer-reviewed open access periodicals) and Green Path (researchers' auto-archiving of copies of their own work in open repositories), and after a specified time lag in the case of publications in traditional periodicals.

The final results, also often intermediate results, of publicly funded research work must be peer reviewed, with these expenses being borne by the grant provider so that the costs of verifying research quality are not incurred by the platform as the distribution channel. The costs of reviewing other archived publications should be paid by their authors, as is the case with traditional scientific periodicals. Authors should also incur the costs of preparing materials for placement in the repository, in the appropriate, standardized format.

4   Projected operating expenses of the SYNAT platform

The SYNAT platform operating expenses will include:
- current operating expenses of the institution administering the platform,

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[4] More examples in [10].
[5] An extensive review of world practices in this area is presented in the ICM report [6], pp. 143-150.

Table 1. The breakdown of annual operating expenses
(*source: own study*)

type of costs			annual
salaries (including taxes) and additional annual remuneration including:			1,105,000
• programmers	2 full-time positions	10,000 zł/month	260,000
• network administrators	2 full-time positions	7,000 zł/month	182,000
• buyers (licence purchase)	2 full-time positions	7,000 zł/month	182,000
• manager	1 full-time position	12,000 zł/month	156,000
• accounting personnel	2 full-time positions	5,000 zł/month	130,000
• other employees	3 full-time positions	5,000 zł/month	195,000
rent	700 m^2/15 euro m^2/month		520,000 *
equipment maintenance and repair	5-10% of the equipment's value		100,000 **
electricity			1,200,000
other costs (travel, office materials, services etc.)			?
		total costs:	2,925,000

* rental rates in Warsaw outside the city center, assuming an exchange rate of about 4.1 zł/1 euro
**10% of the value of the equipment in the amount of 1 million zł is assumed

• costs of maintaining institutional and sector repositories that function separately (do not use the hosting services of the institution administering the platform).

The operating expenses of the institution administering the platform include salaries, rent, utilities, equipment maintenance and repair, travel and other office expenses. These costs were estimated on the basis of information obtained from the managers of ICM UW – the leading institution coordinating the purchase of licences by consortia of institutions of higher learning and other scientific institutions. ICM UW is also responsible for acquiring and network sharing of scientific data bases under the Virtual Library of Science – assuming that the platform operator functions as an autonomous entity.

The breakdown of annual operating expenses is given in Table 1. The breakdown includes "additional annual remuneration", which is a mandatory salary component in public sector entities (institutions of higher learning, executive agencies and state legal persons) – it is not mandatory for private entities.

As stated previously, we assume that the SYNAT platform operator will integrate the activities of domestic institutional and thematic repositories as well as coordinate the purchase of licences granting access to foreign sources of knowledge due to the greater bargaining power this provides, thus greater capacity to negotiate prices. It follows that the institution administering the platform should employ professional buyers.

The operating budget presented above is conservative in character – it assumes, among other things, that:

• 2 programmers will be hired; the actual need in this area could fall anywhere from 1 part-time programmer to 2 full-time programmers,

• equipment maintenance and repair costs will reach the upper limit of the anticipated cost bracket – i.e. 10% of the value of the IT equipment,

• the costs of renting premises are typical Warsaw rental rates, though these figures are relatively high for rents outside the core city centre.

However, this breakdown does not include amortization of capital assets – the basic rate of depreciation for computer equipment is 30%, and it can be raised by a factor of up to 2.0, because computers as capital assets are subject to rapid technological obsolescence.

Also absent from the breakdown are "other costs", including business travel, office materials, services etc.

Electricity constitutes a significant component of operating expenses. ICM UW estimates that the current amount of electricity consumed by the Virtual Library of Science server accounts for about half of this institution's energy costs. Electricity consumption depends on server power – the greater a server's power, the greater the demand for electricity. Thus it will be important to determine the power of the computer hardware the SYNAT platform requires as a factor

generating electricity consumption costs. It would be useful to specify the relationship increase in server power/ increase in electricity consumption.

Increased platform operating expenses could also result from the provision of added services, such as hosting – keeping other entities' institutional or thematic repositories on the platform's servers, performing data search and aggregation in various profiles on demand, consulting in the area of intellectual property rights etc. These costs will depend on the scope of services offered, which on principle should be covered by the service user.

At the current stage it's difficult to calculate the costs of maintaining separately functioning (not using the hosting services of the institution administering the platform) institutional and thematic repositories, because we do not know how many such repositories will be maintained separately and how many will take advantage of the platform's hosting services.

According to ICM UW estimates, "the costs of an institutional repository would stem mainly from adaptation of the existing infrastructure and ongoing operation of the repository.

The costs for one mid-sized repository are roughly as follows:

- server installation and configuration – one-time expense: 1-3 network administrator person-months,
- system administration – fixed cost: 0.25-0.50 network administrator person-months,
- repository management (library work) – fixed cost: 2 repository manager person-months.

It's also necessary to include additional costs stemming from the establishment of an institutional support network for researchers negotiating with publishers. The most effective solution would be to locate (the elements of such a network) by the repositories. They can be expected to be needed especially during the transition period." [6, p. 228]

This estimate constitutes an appropriate starting point for calculating the costs of maintaining separately functioning (not using hosting – so-called in-house repositories) institutional repositories, although calculating the operating expenses that will be generated by all the repositories functioning in the system will require a knowledge of how many repositories there will be.

It's also difficult to estimate the costs of meta-data preparation.

5   Capital expenditures

Assuming that the SYNAT platform operator is an autonomously functioning entity (i.e. is not part of another institution, such as ICM, which is unit of the University of Warsaw), it will be necessary to specify the expenditures on initial capital outlays.

ICM UW estimates that about 1 million zł will be needed to cover these expenditures. Two equipment configuration variants are possible: a single, high-power server or a set of several lower-power servers whose computing power adds up to that of the single server in the first variant. The choice of variant is important in respect to future hardware replacement, which should take place every 3-5 years, depending on the pace of technological progress. In the first case the entire equipment will have to be replaced after several years; in the second case, replacement can take place gradually.

The estimated capital expenditures presented here do not take into account the hardware power ÷ production relationship. Further factors that should be investigated are:

- whether, and to what extent, the installation of computer hardware worth 1 million zł will allow for increased content delivery and service to an increasing number of users (website traffic)?
- at what scale of "production" would it be necessary to increase "production capacity"?

Answers to these questions would enable us to specify the schedule and scale of future additional capital expenditures and the possibility of coordinating them with equipment replacement stemming from technological reasons. It should be kept in mind here that the servers' power will determine electricity costs.

A precise projection of capital expenditures will be possible only after the SYNAT platform operator variant is chosen: on the basis of ICM UW, in which case costs will be limited to the additional hardware needed; or as a whole new organization, in which case it will be necessary to build the IT infrastructure from scratch. For the purpose of covering these expenditures, the institution administering the platform can apply to the Fund for Polish Science and Technology, which is at the disposition of the minister responsible for science.

This is a special fund that is used to implement the "Programme to support research infrastructure"

[19] – funding or co-funding can be obtained for capital expenditures on the purchase or production of scientific research apparatus needed for research. The Fund for Polish Science and Technology may also finance expenditures for purposes relating to the development of Polish science and technology, including the support of particularly important areas of research and developmental work as well as the promotion and dissemination of science. This last purpose indicates the SYNAT platform as a potential beneficiary.

6   Revenue sources for the SYNAT platform operator

In attempting to answer the question as to how SYNAT platform operations should be funded, it must be made clear from the start that scientific and technological information should be regarded as special public goods, also called "social goods" – that is, goods which, owing to their natural characteristics, could be provided for a fee to particular people, but which, in keeping with social and economic policy, should be provided free of charge or at subsidized rates to specified groups or to all citizens. A prerequisite for the creation of social goods is making their consumption possible by people who, due to their individual incomes, would be excluded from access to them if these goods were available only on commercial terms (for a charge)[6]. While social goods are financed by public funds, this does not exclude their financing by private funds. Social goods in Poland include education, health care, culture, sport, urban transportation etc. This category of goods should also include scientific and technical information, understood as universal and free access to knowledge due to its enormous importance for social and economic development. This conception of scientific and technical information implies the necessity of engaging public funds in KSINT, though it also allows for the possibility of funding from private sources. The predominant practice abroad is to fund KSINT operations from public sources.

Likewise in Poland the main source of funding for the INT system must be the government, with private funds playing a supplementary role.

6.1   Revenue from public sources

In connection with this, the question arises as to how to ensure continuity of funding from the national budget in a situation when:

- firstly, the national budget is established on an annual basis, yet the project is long term, and there is no guarantee that sufficient funding will be allocated to KSINT in each successive budget,

- secondly, there is a permanent deficiency of funds for public tasks, competition for the limited funds is intensifying, and science expenditures usually lose this competition.

Taking the above into account, it's necessary to specify steady, autonomous public funding sources that ensure regular revenue to cover the SYNAT platform's operating expenses. Three variants should be considered: 1) Long-term programme; 2) Income tax surcharge assessed on legal persons – an idea advanced by one of the experts supporting implementation of the SYNAT project, prof. B. Samojlika[7]; 3) Charging authors or the institutions with which they are affiliated for depositing research content in repositories.

1) Long-term programme (pursuant to art. 136 of the Public Finances Act [14]):

- the Budget Act may specify, within the expenditure limits for the fiscal year, limits on expenditures on long-term programmes,

- long-term programmes are established by the Government for the purpose of realizing strategies adopted by the Government, including in the areas of defence and state security. The Government, when establishing a programme, shall indicate the entity implementing it,

- the realization of long-term programmes may be divided into stages,

- entities realizing long-term programmes may incur obligations (debts), in particular years, for the purpose of financing the programme's implementation up to the total amount of expenditures specified for the entire programme. In the case of joint realization of a long-term programme by two or more entities, the obligations incurred by each entity may not exceed the amount planned for that entity.

Currently, numerous long-term programmes are under way, e.g. the previously mentioned Kultura+ pro-

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[6] For a broader discussion of social goods in [12], see p. 32 and later.

[7] Opinions of experts in [8].

gramme. The establishment of such a programme ensures funding or co-funding throughout the period it's in effect and allows for phased implementation of complex, long-term projects. The degree to which the final goal has been achieved is specified at each stage.

When recommending a long-term programme as a way to ensure funding to launch and develop the SYNAT platform, it's necessary to set a final goal and sub-goals to be met at each stage – e.g. the degree to which repositories are open, or the ratio of publications in open access to publications resulting from publicly funded grants, or both these metrics and the degree to which they are realized each year. It's also necessary to specify the expenditures toward realization of the final goal – for this reason cost calculations are important, as well as co-financing, when possible, by the beneficiaries of public funds.

The minister for digitization should be in charge of the long-term programme. The SYNAT platform could be the operator of such a long-term programme, and the final beneficiaries would be the repositories – participants in KSINT.

2) An income tax surcharge on legal persons, proposed by prof. B. Samojlik, former Minister of Finance. Assuming a Corporate Income Tax (CIT) surcharge of e.g. 5% at the current 19% CIT rate and revenue from this tax exceeding 38 billion zł in 2011 – the surcharge rate would be 19%*0.05=0.95%, which would yield over 360 million zł in extra revenue to be allotted to the SYNAT project.

This revenue would suffice not only to cover the platform's operating expenses, but also to finance the purchase of licences for access to foreign sources and digitization of scientific library resources. Revenue from CIT can vary according to the state of the economy in the given year, but this revenue would be earmarked for the SYNAT project. Such a solution, though it would require amendments to the CIT Act, would provide an opportunity to market the "innovative" financing of research by business in exchange for free access to the results of this research. It should be noted that CIT surcharges, and surcharges on various taxes, are widespread in the EU. It's also worth considering the option of using income from the CIT surcharge to fund the long-term programme discussed in the previous point.

3) Fees for depositing scientific content in repositories – this would amount to indirect public funding due to the fact that over 90% of scientific research in Poland is financed from the national budget, and researchers would include this fee in the costs covered by their grants. In this variant, the main source of funding should be revenue from fees for mandatory auto-archiving the results of publicly funded research in repositories integrated with the SYNAT platform. Special grants for conducting projects to the NCN and NCBiR in 2012 amounted to nearly 2 billion zł, which should be added to the 2 billion zł allocated to scientific institutions to perform their statutory activity. If the operating expenses of the entities integrated with the SYNAT platform amounted to 10 million zł (the amount estimated by experts), then a 0.25% allocation from all government expenditures on scientific research would suffice to cover these costs. If this funding variant for the platform were adopted, then in addition to introducing the obligation of disseminating the results of publicly funded research, it will be necessary to impose a fee for depositing these works in Open Access archives in order to ensure revenue for the repositories collecting these resources. The repositories would thus gain a steady source of income – their main source of revenue would be fees for auto-archiving publicly funded research works, to be paid by their authors or the institutions with which they are affiliated. The obligation to disseminate scientific research results in Open Access should be a research grant selection criterion, and the costs of meeting this obligation should be included in the research project cost estimate.

The imposition of fees on the authors of publicly funded Open Access publications means that these costs will still be incurred by the national budget, as they will show up in the cost estimates of research grants. But a change in the funding scheme will occur – in the traditional model, it was the libraries of scientific institutions which, for and on behalf of readers, incurred the costs of providing publications. The employees of these institutions decided the contents of their libraries, which did not always satisfy or suffice for all users. But an Open Access virtual library is filled by research authors, and its contents may be incomparably larger and adapted to the needs of all users. This represents added value in the SYNAT business model.

The question arises as to how much to charge for auto-archiving. The costs of publishing a typical article in a professional printed journal are estimated to amount to 1-3% of the costs of the research necessary to create it. Publishing costs mainly consist of expendi-

tures on evaluating the scientific value of an article and editing it, which are easy to calculate. But the cost of depositing and storing one article on a server cannot be calculated directly – thus, certain estimates have to be made, such as the relation of repository network operating expenses to:

- expenditures on science, as indicated above,
- the number of publications auto-archived per year,
- the total size of auto-archived files or some other metric.

6.2   Supplementary revenues – private sources

The SYNAT platform could derive revenues from added services, including:

- hosting resources provided on the platform's servers for other institutions' repositories,
- on-demand searches according to various criteria,
- consulting in the area of intellectual property rights,
- advertising – e.g. for periodicals which, during the [pre-publication] waiting period, provide articles on-line for a fee, or for institutions of higher education,
- providing access to users outside the regular authorized group,
- sponsoring by private individuals and institutions.

If access to the platform's resources were gradually opened to successive user segments, fees could be charged during the transition period to persons otherwise unauthorized to access the content. Finally, when the platform reaches maturity and full openness, sales of services by knowledge and innovation brokers should be included in its offering, to which the authors of a Jagellonian University report call attention [13].

Regardless of the platform's main sources of revenue, it should seek business partners who would be interested in supporting selected aspects of the platform's activities. These could be industrial corporations that support the delivery of appropriately processed knowledge to particular user segments, publishers interested in attracting attention amongst a broad range of potential readers, IT sector manufacturers interested in their products being used by a renowned organization, Internet search engines, repositories outside the INT system and others.

To recapitulate, the SYNAT platform's main revenue stream should come from public sources, and appropri-

ate legal regulations would need to be adopted for each of the three public funding variants. Other, non-public funding sources – mainly from sales of services – would be supplementary in character.

7   Proposed organizational-legal solutions

Assuming a centralized coordination system as well as public and non-public funding, the choice of organizational-legal forms for the institution administering the SYNAT platform is broad, ranging from public sector entities (executive agency, state legal person), through public law foundation, to commercial companies. The choice should be determined by the outlook for ensuring the long-term continuity of funding, thus the continuity of KSINT operations.

The main organizational form for conducting large-scale business activity is the commercial company. Organizing business activity in the form of capital companies is advantageous due to the limitation of liability for the company's obligations to the company's assets; shareholder liability is limited to their contributions to the company. Capital companies have fairly formalized structures, since they regulate the rules of shareholders' limited liability. Limited Liability companies (sp. z o.o.) have less formal structures, while Joint-Stock companies (S.A.) are more formalized.

However, due to the character of the product offered by the analysed project (social goods), and the fact that public funds constitute the main revenue stream of the institution administering KSINT, the form of organization that should be considered first is public sector entity. Among the public sector entities mentioned in the Public Finances Act [8] as organizational-legal forms, the SYNAT platform operator should consider executive agency and state legal person. The main differences between these solutions boils down in practice to the character of their revenue sources – executive agencies obtain the funding they need to perform their tasks primarily in the form of national budget allocations (56,3% of total revenue in the draft 2012 national budget act) or revenue derived from administration of state assets entrusted to them, while state legal persons have defined on going sources of revenue and do not obtain significant budget allocations (2,6% of total revenue in the draft 2012 national budget act) [3].

7.1   Executive agency

These agencies are heterogeneous entities in organizational and legal structure, and there is no legal definition of them. Government entities called agencies may function (or functioned in the past) in the form of Joint-Stock companies in which the State Treasury is a shareholder, State Treasury foundations, budgetary units, budgetary institutions and finally legislatively established state legal persons. This part of the paper refers to the latter type and is intended to provide an abbreviated presentation of the most important elements of government agencies functioning as legal persons.

Examples of government entities functioning as executive agencies include the National Science Centre, National Centre for Research and Development and Polish Agency for Enterprise Development. Agencies perform a variety of tasks, which can be grouped as follows:

1) managing assets belonging to the State Treasury, including buying and selling;

2) privatizing and managing state reserves (ARR, ANR, AMW, WAM);

3) implementing government policy within designated areas, by means of intervention, restructuring, promotion, information provision, education and social activities (NCBiR, NCN, ARR, ARiMR, ANR, PARP);

4) conceptual work, planning and design (ARR);

5) attracting foreign investments and supporting activities to promote Poland abroad (PAIiIZ).

The tasks of agencies and the tools for performing them are defined in the legislative acts that establish them. However, in several cases – e.g. Agency for Restructuring and Modernization of Agriculture, Polish Agency for Enterprise Development – the legislature delegated the specification of tasks, directions of activity and means of implementation to executive regulations.

Government agencies are supervised by the Prime Minister and other ministers depending on the type of agency and the ministry to which it is subordinated. The officer directing and representing the agency is its president, who is most often appointed by the Prime Minister at the request of the minister supervising the agency.

The Public Finance Act of 27 August 2009 [8] introduced a new form of public sector entity, the executive agency. This entity form is new in that the Act uniformly specifies certain general rules governing the financial management of entities hitherto called "state agencies" or "state government agencies". The rules previously governing the financial management of these agencies were specified in the legislative acts that gave birth to them. Now, the Public Finance Act provides for the financial management of executive agencies based on the provisions of this act as well as the act that established the given agency.

An executive agency is a state legal person established pursuant to a separate act for the purpose of performing government tasks. It's a solution modelled after common practice in the EU, where the performance of particular tasks is entrusted to executive agencies, not only EU bodies. In Poland, these tasks had been performed by a certain portion of the so-called government agencies. An executive agency acquires legal personality by the legislative act that establishes it. This act should also specify whether, and in what registry, this fact is noted.

The basis for the financial management of an executive agency is its annual financial plan, consisting of the following items:

1) revenue from activities conducted;

2) allocations from the national budget;

3) cost breakdown:
   a) agency operations,
   b) performance of statutory tasks, with a specification of the costs of performing these tasks by other entities, including salaries and contributions [taxes] assessed on them, interest payments resulting from incurred obligations and purchases of goods and services;

4) financial result;

5) funds for capital expenditures;

6) funds granted to other entities;

7) assets and liabilities at the beginning and end of the year;

8) cash and cash equivalents at the beginning and end of the year.

The executive agency financial plan constitutes an annex to the Budget Act, while its financial statement constitutes an annex to the Report on the Implementation of the National Budget.

An executive agency financial plan has a structure typical of any public sector entity. However, it also has certain differences. The first is the obligation to draw

up the agency's revenue and expenditure plan according to time of payout. The second is the requirement to ensure that the agency's planned revenues and expenditures are balanced, although this requirement may be waived by the agency's supervisory body in consultation with the Minister of Finance. The third difference is the imposition of limitations on changes in an agency's financial plan. The fourth is the imposition of restrictions on incurring obligations for implementation of a given task over a period exceeding the fiscal year. The fifth is that an agency may receive allocations from the national budget without precisely specifying the character of the allocations. This means that an executive agency's financial autonomy, as a separate legal person, is very limited.

An executive agency is required to pay surplus funds remaining after payment of all taxes (as determined at the end of each year), into the national budget. However, the Government, at the request of the minister supervising the given agency, may agree (in the form of a resolution) to waive this requirement. The reason for requiring executive agencies to pay their surplus funds into the national budget is the non-profit character of these agencies – since they cannot keep surplus funds (profits) for themselves, they should not be motivated to generate them.

Currently, agencies are also obliged to comply with the Public Procurement Act. The State Treasury is not liable for the obligations of agencies, and agencies are not liable for the obligations of the State Treasury, although this rule does not apply, for obvious reasons, to agencies performing tasks for or on behalf of the State Treasury (WAM, AMW, ARM) [22, p. 13].

The detailed provisions governing financial and asset management by executive agencies lie in the legislative acts establishing them, their statutes (charters) and numerous executive regulations which apply to particular agencies.

The powers and duties of an agency relating to financial management include: incurring short-term loans, incurring long-term loans, issuing bonds, obtaining guarantees from the State Treasury for obligations arising from the aforementioned actions, granting guarantees for loans, subsidizing interest payments on loans, issuing loans or grants, funding or co-funding supported enterprises, acquiring and taking over shares and stock in commercial companies, acquiring bonds issued by enterprises, selling debts.

If the SYNAT platform operator functioned in the form of an executive agency, its revenue would consist of:

- earmarked allocations to cover operating expenses,
- special allocations to buy licences for scientific data bases,
- allocations for capital costs,
- other revenue, e.g. income from the sales of services, interest earned on funds in bank accounts etc.

Supervision of the SYNAT platform in the form of an executive agency would be exercised by the Ministry of Administration and Digitization, which wants to uniformly standardize the rules governing access and use of publicly funded knowledge resources, [and] declares that its aim is the openness of public knowledge resources, understood as information resources of special importance for the innovation and development of an information society as well as other sources of knowledge and cultural content belonging to cultural, scientific and educational institutions [11]. The Ministry of Science and Higher Education, Ministry of Culture and National Heritage and Ministry of Education should also be administrators of funds granted to cover the platform's activities.

If the platform is organized as an executive agency, its continuity of funding will depend on the state of the national budget. If difficulties arise expenditures may have to be cut, and often planned capital expenditures are the first items crossed off the budget, which could pose a threat to the normal functioning of the platform.

7.2   State legal person

Examples of state legal persons are the Office of Technical Inspection, Polish Centre for Accreditation, Polish Air Navigation Services Agency, the Polish Film Institute and the Social Security Administration (ZUS). State legal persons[8], like executive agencies, are established pursuant to separate legislative acts. They pursue the economic aims of the state and perform specified public functions.

The basis of the financial management of state legal persons is a financial plan, drawn up pursuant to the

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[8] A state legal person should be understood as an organizational unit other than the State Treasury, having a legal personality, whose property is entirely state property. Act of 8 August 1996 on the Rules Governing the Exercise of Treasury Powers (Journal of Laws 1996, No. 106, pos. 493, as amended).

legislative acts establishing them, taking into consideration provisions of the Public Finances Act, and presented to the Minister of Finance in the manner and within the time limits specified in the regulations governing preparation of the Budget Act. These entities manage their finances autonomously, covering expenditures on their legally defined tasks with their own funds and revenues they obtain. They have their own assets which constitute state property in an economic sense, but they are not liable for obligations incurred by the State Treasury. They may use the revenue they obtain to make capital expenditures. Depreciation of capital assets is included in their operating expenses.

State legal persons obtain revenue from the activity they conduct and from national budget allocations. Revenue from activity includes fees for actions/ services performed for other entities. Performance of these actions is mandatory. The relatively steady demand for these services (the performance of particular actions is often a requirement that must be satisfied before an enterprise, or its products or services, can enter the market) ensures stable revenue for entities with the status of state legal person.

If the SYNAT platform operator had the status of a state legal person, its revenue would consist of:

- income from the basic activity it conducts,
- special allocations to buy licences for scientific data bases,
- other revenue, e.g. income from the sales of added services, income from assets, interest earned on funds in bank accounts, other revenue etc.

As in the case of executive agencies, the SYNAT platform operator as a state legal person should be subject to supervision by the Ministry of Administration and Digitization, and the Ministry of Science and Higher Education, Ministry of Culture and National Heritage and Ministry of Education should also administrate funds granted to cover the platform's activities.

7.3   Foundation

Because the SYNAT platform operator performs tasks of a public nature, and should be funded by the national budget, it could assume the form of a public foundation, which, though not considered to be public sector entity, may receive public funding.

An example of a public foundation is the Public Opinion Research Centre (CBOS), which was established by a legislative act [1].

The Law on Foundations of 6 April 1984[9] does not contain a direction definition of a foundation, mentioning only its basic characteristics:

- a foundation is established to pursue socially or economically useful aims that are consistent with the basic interests of the state, in particular: health care, economic and scientific development, education, culture and art, social security, environmental protection and conservation of historical monuments,
- founders may be any natural persons, regardless of citizenship and place of residence,
- a foundation is a legal person, and it acquires legal personality the moment it is entered in the National Court Register,
- a foundation is under the supervision of state bodies, although all decisions concerning the foundation itself – including entry in the register, repeal of resolutions adopted by the board, suspension of the board or liquidation of the foundation – are made by the registration court,
- after it is registered, a foundation functions at the request of the minister within whose purview the foundation's purpose lies or the provincial governor.

The constitutive elements of a foundation according to Polish law are: 1) assets, 2) public purpose, 3) non-corporate organizational structure that has a legal personality.

The following types of foundations can be distinguished:

- private and public foundations: Polish law allows the establishment only of foundations with a public purpose – i.e. serving the interest of some unspecified group of beneficiaries,
- private law and public law foundations: the former are established pursuant to provisions of private law, i.e. by way of legal actions; the latter type of foundation is established by legislative or administrative acts; a regulation under the Law on Foundations currently makes it impossible to establish a foundation by way of acts issued by state bodies,

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[9] Journal of Laws 1991, No. 46, pos. 203, as amended.

- non-profit and not-for-profit foundations: the former cannot conduct business activity, and their assets are funded solely by gifts, bequests, grants etc.; pure non-profit foundations are very rare in Poland; not-for-profit foundations are more frequent; this type of foundation may conduct business activity, but all revenues it obtains must be devoted to the foundation's statutory activity; profits must also be devoted to covering the foundation's operating expenses or maintaining its capital.

Foundations may be established by natural persons or legal persons. While they may not be established by the State Treasury, they can be created by provincial and district (powiat) governments.

A foundation's charter (statute) may contain a provision enabling it to conduct business activity. Such a provision, however, is optional, and its absence would merely render the foundation incapable of conducting business activity. For-profit business activity may not be the means by which a foundation realizes its main goals. Not-for-profit business activity (in which fees are collected only to cover necessary operating expenses) may be a means by which a foundation pursues its goals, thus it may be properly regarded as lying within the meaning of a foundation's statutory activity, but only when it is consistent with the public interest – that is, it's the only way to satisfy particular social needs; thus, only business activity that lies within this scope is consistent with a foundation's statutory activity. In practice this means that a foundation must address its activity to people whose needs are not satisfied according to regular market principles. Conducting profit-making business activity is essentially the only way to obtain funds for a foundation's statutory activity, thus it performs a subsidiary function in relation to pursuit of a foundation's non-profit-making goals. This business activity must conform and be subordinated to the foundation's statutory activity – that is, at least the majority of income from a foundation's business activity must be devoted to its statutory goals [21, pp. 157-158].

If the SYNAT platform operator had the status of a foundation, its revenues could consist of:

- income from statutory activity,
- special grants to buy licences for scientific data bases,
- grants, donations, legacies and bequests,

- other revenue, e.g. income from the sales of added services, income from assets, interest earned on funds in bank accounts, other revenue etc.

A foundation – in contrast to the other organizational-legal forms presented earlier (executive agency, state legal person) – may obtain revenue from grants, donations, legacies and bequests, which opens the way to financing by its founders. However, it must apply for grants on a competitive basis. Revenue from activities would provide the platform operator as a foundation steady funding for its operations, while the costs of buying licences would be covered by the national budget and donations.

7.4   State institution in the form of a joint-stock company

Another possible organizational model for the SYNAT platform operator is joint-stock company. We will present two solutions here: joint-stock company with the status of a public benefit company and non-profit public company modelled after the National Depository for Securities.

The joint-stock company is an organizational-legal form meant for conducting larger-scale business activity. Consequently, its regulations are the most formalized of all the regulations governing the various organizational forms of enterprises.

A joint-stock company may be formed for any legally permitted purpose, not only for conducting business activity, by one or more persons (though it cannot be founded by a single-member limited liability company). Joint-stock companies can be divided into private and public companies. The latter are characterized primarily by the fact that their shares are publicly traded[10]. To establish a joint-stock company it's necessary to organize it, make contributions that cover the share capital in its entirety, appoint a board of directors and supervisory board, and enter the company in the register. Only at the moment a joint-stock company is entered in the register does it acquire a legal personality.

A joint-stock company, as an entity separate from its shareholders, is solely liable for its obligations – thus, its shareholders incur no liability for its debts.

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[10] See art. 4 § 1 pt. 6 of the Commercial Companies Code in connection with art. 4 pt. 20 Act of 29 July 2005 on Public Offerings, the Conditions Governing Introduction of Financial Instruments into Organised Trading, and on Public Companies. (Journal of Laws 2005, No. 184, pos. 1539, as amended).

The minimum initial capital required for a joint-stock company is 100,000 zł, which is divided into shares. A share may not be worth less than 1 grosz.

Choosing a capital company as the organizational form of an enterprise is justified if its activity is to be conducted on a large scale. The establishment of such a company entails certain expenditures, primarily in the form of the initial capital, which must meet the minimum requirements. It's also necessary to incur the costs of maintaining the governing bodies of these companies. An advantage of choosing a capital company as the form of doing business is the significant limitation on liability it affords. It's only the company itself that is liable to creditors. Shareholders are not liable for the debts of the company, at least in a legal sense.

If the SYNAT platform operator were organized in the form of a joint-stock company, it would be important to note the position taken by the Supreme Court – Civil Chamber, stated in its Resolution of 13 January 2006 (III CZP 122/2005 (OSNC 2006/12 poz. 200)), where it ruled that a "joint-stock company conducting socially useful activity in the sphere of public tasks specified in the Public Benefit and Volunteer Work Act of 24 April 2003[11] and not operating for the purpose of making a profit may acquire the status of a public benefit organization".

It should be noted, however, that non-government organizations and other entities may acquire the status of public benefit organization provided that they have conducted socially useful activity in the sphere of public tasks continuously for at least 2 years. Moreover, non-government organizations and other entities subject to entry in the National Court Register acquire the status of public benefit organization the moment information is added to the Register stating they have met these requirements on the terms and in the manner prescribed in the National Court Register Act of August 20, 1997[12].

Pursuant to art. 24 of the Public Benefit and Volunteer Work Act of 24 April 2003, public benefit organizations are exempt from:

- corporate income tax,
- property tax,
- taxes on civil law transactions,
- stamp duty (treasury fees),
- court fees

in relation to the public benefit activities they conduct.

Public benefit organizations may be charged with the performance of public tasks in two forms: 1) being entrusted with performing public tasks, and being provided grants to finance their realization; 2) supporting the performance of public tasks, and being provided grants to co-finance their realization.

Public benefit activity is not business activity, though it may be conducted either free of charge or for a charge. Public benefit activity conducted for a charge is: 1) activity conducted in the sphere of public tasks for which remuneration is collected; 2) the sale of goods or services produced or rendered by persons directly benefitting from public benefit activity.

Revenue from public benefit activity conducted for a charge is devoted solely to conducting the public benefit activity[13].

Public administration bodies support the realization of public tasks by public benefit organizations and entrust the performance of public tasks to them. This takes place after conducting an open tender, unless separate regulations provide for a different mode of commissioning. Supporting and entrusting these tasks may take place on the terms and under the provisions of Public-Private Partnership.

A prototype for another organizational-legal form that the SYNAT platform operator could adopt is the National Depository for Securities (KDPW).

In Poland, KDPW is the central institution responsible for the management and supervision of the depository-settlement system in relation to trading in financial instruments in Poland. Essentially, it's an electronic platform on which financial instruments are registered (depository) and transactions in securities trading are settled; it also realizes the obligations of issuers to investors[14].

KDPW functions as a self-supporting, independent joint-stock company. A third of its shares belong to the State Treasury, represented by the Minister of the Treasury; a third, to the Warsaw Stock Exchange; and a third to the National Bank of Poland (NBP). Shares in the Company may be acquired only by operators of financial instrument trading platforms, investment firms, banks, the State Treasury, NBP and legal

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[11] Journal of Laws 2003, No. 96, pos. 873.
[12] Journal of Laws 1997, No. 121, pos. 769.

[13] Art. 6-8 Public Benefit and Volunteer Work Act of 24 April 2003 (Journal of Laws 2010, No. 234, pos. 1536).
[14] This list, of course, does not exhaust all the tasks performed by KDPW.

Table 2. Comparison of funding prospects for the SYNAT platform operator according to organizational-legal form
(*source: the author of this report*)

organizational form	strengths	weaknesses
executive agency	• certainty of funding • ease of obtaining funding from the national budget • possibility of obtaining funding from defined sources of revenue earned from activities	• lack of incentives to maximize revenue • no way to obtain private funding (sponsoring)
state legal person	• ease of obtaining funding from the national budget • greater possibility of obtaining funding from defined sources of revenue earned from activities	• lack of incentives to maximize revenue • no way to obtain private funding (sponsoring)
foundation	• possibility of obtaining funding from revenue generated by activities • funding can be obtained from donations and bequests • tax breaks for foundations with the status of public benefit organization	• no way to obtain funding from the national budget • public funding can be obtained only on a competitive basis
company with status of a public benefit organization	• possibility of obtaining funding from various revenue-generating activities • the greatest prospects for obtaining funding from financial markets • tax breaks for foundations with the status of public benefit organization	• high founding and administration costs • no certainty of obtaining public funding • public funding can be obtained only on a competitive basis
non-profit company	• full autonomy in shaping sources of revenue • the greatest prospects for obtaining funding from financial markets • possibility of reducing the government's stake in the company	• high founding and administration costs • public funding can be obtained only on a competitive basis

persons or other organizational entities that conduct activity in the field of registering financial instruments as well as clearing or settlement of transactions in securities trading or the organizing of a regulated market and are based in a country that belongs to the EU, EEA or OECD, provided they are subject to supervision by the appropriate supervisory body of this country. The company's shares are exclusively ordinary and registered. The company is non-profit [20].

Securities depository participants may be investment firms, state institutions such as the Central Bank or State Treasury, issuers of securities, banks, insurance companies, pension funds and investment funds, provided they invest funds on their own account in the securities market, entities authorized to clear or settle transactions in financial instruments trading and foreign depositories of financial instruments.

KDPW's source of revenue are fees collected from participants for managing the depository, such as the fee for opening a formal account, fee for the management of an entity account, fees for safekeeping cash

market instruments, shares, treasury bills and other securities (collected on a monthly basis, calculated according to the market value of the securities held on participants' registration accounts), settlement fees (collected on a monthly basis from participants who are settlement counterparties) and fees for additional services. Fees are also collected from issuers as participants in KDPW [15].

If the SYNAT platform operator assumed the form of a joint-stock company modelled after KDPW S.A. it should be established by the State Treasury (represented by representatives of Ministry of Science and Education, Ministry of Education, Ministry of Culture and National Heritage, Ministry of Administration and Digitization). It would be advisable to allow shares to be acquired by other entities that support science, culture and education – e.g. the National Centre for Research and Development, National Science Centre, Foundation for Polish Science and companies in which the State Treasury holds a stake, which would

allow the government to gradually withdraw from the company in future[15].

A summary of the strengths and weaknesses in respect to funding continuity of the possible organizational-legal forms for the SYNAT platform operator is presented in Table 2.

The platform's business partners should be: public and private institutions of higher learning, Polish Academy of Sciences, scientific and research institutes, Foundation for Polish Science, libraries, publishing houses and other entities that support science, culture and education. Institutions that keep repositories of the results of publicly funded research should be required to participate in the SYNAT platform. Participation by other repositories should be optional.

Revenue sources for the platform's operator would include server hosting fees, income from the sale of added services, proceeds from advertising etc. The basis for estimating the amount of these fees needs to be determined – what should the platform's operating expenses be referred to: the magnitude of a participant's resources, the quality of resources as measured by bibliometric points, average time lag from the moment an article is published to the moment it's archived, or some other metric? If the institution managing the SYNAT platform maintains its own repository, fees for depositing content in it would be paid by the content providers.

It should be noted that the form of joint-stock company modelled after the National Depository for Securities S.A. would pose an obstacle to using public funds to buy national licences for scientific data bases – this could be treated as public assistance for business entities, which in principle is prohibited in EU member states.

Subsidizing enterprises requires the permission of the European Commission. An alternative could be special grants awarded to platform participants; the total amount of the grants would cover the costs of buying such licences by a consortium coordinated by the platform. There would be no such problem in the case of a joint-stock company with the status of a public benefit organization.

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[15] Interest in the education and science sector is beginning to be shown, for instance, by investment funds – Kopernik FIZAN, set up by TFI Copernicus, intends to invest in non-public institutions of higher learning, science centers and research institutions [17].

8   Summary and conclusions

The costs of obtaining content from foreign sources and digitization of domestic resources are the main expenses that will be incurred by the SYNAT platform, and are difficult to estimate precisely. The operating expenses of the institution administering the platform, according to conservative initial calculations, should not exceed 3 million zł a year (at current prices), and capital outlays should amount to about 1 million zł. More precise cost projections will require specification of technical assumptions.

Public funds should be used to buy licences granting access to the data bases of renowned publishers of scientific periodicals and to pay for the digitization of Polish knowledge and national heritage resources.

Publications that result from publicly funded research should be subject to mandatory archiving in Open Access repositories. Open mandates should be adopted by the institutions funding science in Poland: NCBiR, NCN, institutions of higher learning, PAN, scientific institutes whose employees conduct publicly funded research within the scope of these institutes' statutory activity, and other institutions that distribute public funds for scientific grants. Other research sponsors could be encouraged to adopt Open Access mandates by means of tax preferences, for example.

The SYNAT venture will not generate sufficient revenue from its activities to cover the platform's operating expenses in the near future or in the long term. Thus, public funds must constitute its main source of revenue; private funding will only play a supplementary role.

There are three possible variants ensuring the SYNAT platform steady funding: a long-term programme established by the Government, a surcharge on Corporate Income Tax, or the payment of fees by authors or the institutions with which they are affiliated for depositing the results of publicly funded research in repositories.

Continuity of funding for a universal, open, repository hosting and communication platform for web-based knowledge resources for science, education and an open knowledge society based on the executive agency model will depend on the condition of the national budget.

The long-lasting and stable functioning of the SYNAT platform under the legal status of a state legal person, public foundation or state institution in the form of a joint-stock company would require that this institu-

tion, and the other institutions linked to its network, be assured of steady (independent of short-term political pressures) sources of revenue constituting an alternative to uncertain direct funding from the national budget.

Calculation of fees for auto-archiving/ the CIT surcharge/ the amount of funding in a long-term programme should be based on the operating expenses of the repository network and the SYNAT platform operator.

An alternative to charging authors or their institutions for the costs of Open Access publication could be special public-private or private funds, the creation of which could be encouraged by tax preferences.

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DECISION-MAKING IN FLAT AND HIERARCHICAL DECISION PROBLEMS

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Abstract: The article is dedicated to the modelling of the essence of decision-taking processes in flat and hierarchical decision problems. In flat decision problems particular attention is drawn to the effectiveness of strategies in seeking decision variants on solution decomposition trees, taking into account the strength of their predefined contradictions. For hierarchical decision processes, the issue of iterative balancing of global (hierarchical) decisions is expressed, based on the valuation of the significance of flat decisions.

Keywords: hierarchical decision problems, modelling of decision-taking processes, AIDA technique, valuation of decisions, solution tree decomposition procedure, flat decision problems with internal contradictions.

1   Introduction

Taking decisions in a flat decision problem (or in other words: in a single-layer system) involves the defining of the decision problem in the form of a set of homogenous decision areas, and determining for each decision variant one elementary decision from each of these areas. Details on how to proceed are presented on the example of the AIDA technique [14] drawn up by J. Luckman. Flat decision problems refer to the execution of simple tasks involving the choice of one from numerous alternative decisions, fully prepared beforehand. An example of a flat decision problem could be the selecting of an offer in a tender, following assessment of the offers in line with the specification of the relevant conditions in the order (in which case one decision area corresponds to each criterion for assessing the offers submitted).

An hierarchical decision problem arises when elementary decisions in insufficient (hypothetical) form for the direct carrying out of assessments and comparisons occur in at least one decision area of the decision problem being analysed. In such a situation the decision areas with hypothetical elementary decisions should be expanded either directly or indirectly into the form of flat decision problems.

Preparation of a nonempty set of decision variants followed by the indication of one of its components "for execution" constitutes the essence of any decision process. In the case of an hierarchical decision problem, the decision area whose elementary decisions emerge as a result of resolving the decision problem situated in the layer directly preceding the decision area's layer (see Fig. 5), i.e. through the consolidation of one elementary decision from each decision area of the decision problem being resolved, corresponds to the set of decision variants in a mutually explicit manner.

The indication of a decision variant as a decision should be preceded by valuation of its individual elementary decisions and the relations of contradiction occurring between them. The calculative complexity of this process belongs to the NP class – difficult due to the exponential dependence of the number of operations of comparing pairs on the number of sets of elementary decisions participating in creation of the decision space (see chapters 3 and 4).

2   The essence of the decision process

Decisions are taken at various levels of management – operational, tactical and strategic – resulting rather from the organisational necessities of management processes and not the essence of the actual decision-taking process, which in a procedural respect cannot always be formalised and frequently derives directly from work regulations or remains intuitive. The classification of management levels derives historically from needs and applications which, initially, were above all military, followed by those of an economic and administrative nature.

A turbulent economic context forces enterprises to adapt quickly to their environment and react accordingly to transformations taking place. Changes must also frequently affect long-term goals. This is reflected in the necessity to harmonise strategic plans on numerous levels with changes and decision of a medium-term

and current scope, on the execution of which the success of strategic goals depends.

Three types of decision are distinguished in decision processes: operational, tactical and strategic. Examples of operational decisions are: employing a new member of staff; purchasing document scanning equipment needed for the management system; and increasing the number of parking spaces. Operational decisions are taken by airport personnel controlling flights and air space, by entire states or even by a continent. However, the consequences of operational decisions taken may be tactical or even strategic in character, depending on the circumstances (the conditions, the threats) in which they are taken.

Tactical decisions, in an operational perspective, apply to the planning and organising of resources and processes essential for carrying out operational tasks, but in a strategic perspective their task is to ensure the conditions for executing an organisation's strategic (long-term) plans.

Tactical decisions apply to the planning and organising of resources and processes essential for the direct execution of operational decisions. The goal of taking decisions at a tactical level is to ensure an enterprise with the effective functioning of material and informational infrastructure. Tactical decisions are reserved for medium-level management or the managerial boards of the organisations in which they are taken. The time horizon for carrying out and assessing the direct consequences of tactical decisions should not exceed one year. Examples of tactical decisions: implementation of an IT Decision Support System (DSS); compiling a prospectus for a planned stock market flotation; and initiating online sales of products and services.

Strategic decisions apply to the planning and allocation in time and space of processes and resources which will be essential for achieving an organisation's strategic goals via appropriate decisions on the tactical level. Strategic decisions are most often reserved for organisations' managerial and supervisory boards. The time horizon for strategic decisions is usually a few years, and is significant for the enterprise or organisation in economic or social-political terms.

The character and time horizon of tactical and strategic decisions is determined by the period after which there should be a return on the expenses incurred along with the appearance of benefits reflecting the operational, tactical and strategic goals – depending on the size of the organisation and the magnitude of the decisions taken.

Among other things, decision processes demand: the systematic accumulation and analysis of information on the goals, resources and processes of the organisation and its context; the development of methods and tools serving the preparation and selection of decisions from among alternative decision variants, as well as the compilation of decision process assessment criteria and the monitoring of their values.

3   Flat and hierarchical decision problems

A decision process may proceed in a single problem layer (flat decision problem) or may take on a multi-layered form (hierarchical decision problem). Flat decision processes refer to the execution of simple tasks, for example involving the processing of a single resource or consolidation of resources available in line with a known procedure (technology). The preparation of alternative decision variants entails defining, for the decision problem posed, corresponding decision areas from which component decisions (elementary decisions) will be drawn in such a way for them to mutually complement each other and display only minimum contradiction in relation to each other in the decision variant being constructed.

The models for flat and hierarchical decision problems derive from the morphological analysis of related decision areas, proposed in 1948 by F. Zwicky [17][1]. Among the numerous known methods of morphological analysis (the morphological box method, the randomisation method using fuzzy sets, Moles' method, and the sequential model of steering events), the AIDA technique (an acronym of the words Analysis of Interconnected Decision Areas) developed by J. Luckman stands out in its high level of effectiveness and simplicity. The AIDA technique may be applied for solving many problems whose morphological models take on a finite, grainy form.

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[1] Creator of the grounds for morphological analysis and discoverer of neutron stars, the Swiss astrophysicist F. Zwicky (1898 – 1974) treated morphological research as "glimpsing such a picture of reality in which all the major structural connections between objects, phenomena, ideas and actions would be clearly taken into account…"
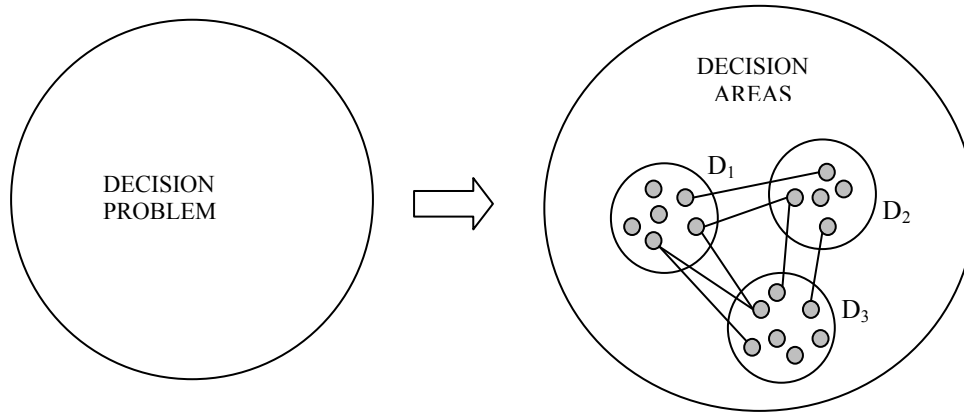
Figure 1. Model of a flat decision problem; D_1, D_2, D_3 – decision areas and their elementary decisions (*source: the authors*)

Distinguishing between a flat and hierarchical (multi-layered, see Figs. 1 and 5) decision problem boils down to resolving whether the decision problem expressed for a specific issue may be settled (resolved) without having to consider more detailed issues and as a consequence expressing separate decision problems for them. Hence the decisions on a strategic and tactical level should be taken as solutions to hierarchical problems, while operational decisions are by definition the solution to flat decision problems. All data at the operational level should be attainable without having to take decisions on more detailed (elementary) levels. With a flat decision problem we are dealing purely with a situation in which the elementary decisions have already been taken, and their results (the products) are available for combining (consolidating) into decision variants.

The essence and expression of a decision problem may be presented in various ways depending on the language convention adopted for the formal record of the problem situation's model. For our needs, in order to obtain a general expression of a decision problem, we will be using the convention used in the AIDA technique (see Fig. 1).

In the language of the AIDA technique a decision problem is recorded in the form of a finite set of decision areas, each of which in turn is a finite set of elementary decisions. The elementary decisions (the points marked in grey in Fig. 1) belonging to the single decision area D_i are alternatives in relation to each other, meaning that a particular elementary decision contained in the decision model excludes the introduction of a different elementary decision from the same decision area. Likewise, elementary decisions from different decision areas declared as in contradiction with each other

(the points in Fig. 1 belonging to different decision areas D_i joined by an unbroken straight line) are excluded from the solution (the decision). Thus we have constructed a model of the problem situation and its solution in the form of a decision. A typical decision process comprises a few phases, among which one can distinguish:

- the problem situation model, in which the essence of the decision problem being resolved and the expected solutions for this problem should be recorded in a formalised manner,
- the decision model, specifying all required attributes and values of the features characteristic for the decisions taken,
- the model of solving a problem situation, enabling – based on the problem situation model and decision model – presentation of the process of generating a set of alternative decisions and distinguishing (indicating) within it the solutions most favourably fulfilling the criteria adopted for assessing the decision.

The phases in the decision process enable presentation of the action cycle leading from the essence of the decision problem, through the desired decision model, up to the generation and relative multi-parametric assessment of decisions selected from the problem situation model. The linked decision areas of the decision problem under consideration are analysed using the solution tree of the AIDA technique, presented later in this article (see Fig. 3), this technique deriving from the apparatus of the so-called morphological analysis ([3], [4], [5] and [17]). The model of the decision recorded in the convention of the AIDA technique is a (brief) sequence of elementary decisions, one from each of the decision areas D_i, of the form…

$$<d_{j1}, d_{j2}, ..., d_{jm}> \tag{1}$$

…and this sequence belongs to decision space D of the decision problem in question, this space noted down as the Cartesian product of the decision areas D_i:

$$D_1 \times D_2 \times ... \times D_m \tag{2}$$

4 The AIDA technique

The essence of the AIDA technique boils down to:

- defining a finite set of internally alternative decision areas $D_i \in D$, describing the posed problem situation,

- defining finite sets of elementary decisions d_{ji} for all decision areas $D_i \in D$,

- defining pairs of mutually contradictory elements d_{ji}, d_{kl} (elementary decisions) belonging to different decision areas D_i, D_l,

- obtaining solution variants by generating all possible sequences of elementary decisions $<d_{j1}, d_{j2}, ..., d_{jm}>$ and eliminating those sequences from decision space D in which pairs of contradictory elements d_{ji}, d_{kl}, occur,

- putting in order, analysing and ultimately choosing acceptable solution variants (decisions), one of which will be taken.

The initial phase of morphological analysis is definition of the decision areas recorded in the form of so-called formative sets of elementary decisions contained in these areas. We create as many formative sets as there are decision areas. Each of the formative sets should contain at least one elementary decision. The elementary decisions of each decision area have homologous properties, i.e. in specific solution variants they may be replaced by other elementary decisions from the same decision area. The Cartesian product of all decision areas demarcates the morphological analysis space (decision space D).

In certain practical applications the AIDA technique may significantly accelerate the generation of and orderly searching through a significant number of decision variants which should be taken into account, particularly in situations of limited time for taking a decision or due to the significant costs of drawing up decision variants. It is not difficult to notice that even with 5 decision areas, each containing 10 elementary decisions, we are forced in a simple morphological analysis to carry out 4.5×10^6 operations of comparing pairs of elementary decisions in order to exclude erroneous (incomplete) decisions in the sense of their formula (1) – and in the case of 10 decision areas each

with 20 elementary decisions, the number of operations for comparing pairs of elementary decisions increases to 1.9×10^{15}.

5 Valuation of decisions

The generation and analysis of decision variants is significantly speeded up thanks to the application of the graph model and orderly decomposition of decision areas. Constructing a graph model of decision space begins with elimination of those decision areas whose formative sets only contain a single element, because – by definition – such an elementary decision will belong to every decision.

The vertices of a graph corresponding to the elements of a single decision area are alternatives in relation to each other (they cannot belong to one decision). Because of the apriori collisions (contradictions) of certain elements belonging to different decision areas, we connect the appropriate graph vertices marked with these elements with edges (unbroken lines).

Figure 2 illustrates the procedure. A dotted line is used to mark elementary decisions forming an example of a correctly constructed decision, in which there are no pairs of elementary decisions constituting alternatives for each other (no contradiction). No pair of elementary decisions belonging to different decision areas can, in a correctly constructed decision, be a pair of elements connected by an unbroken line. An example of another correctly created decision is the sequence: $<d_{21}, d_{22}, d_{23}>$. In the decision problem example we are looking at, there are 7 such correct decisions, which we will demonstrate when building the solutions tree (see chapter 6).

The decision areas and sets of elementary decisions contained within them have imposed upon them, for practical reasons, restrictions valuing by percentage the significance of decision areas V_i and the weightings v_{ji} of the significance of elementary decisions of all decisions areas, where the sum in each decision area is taken for normalisation as equal to 1:

Example (see Fig. 2)

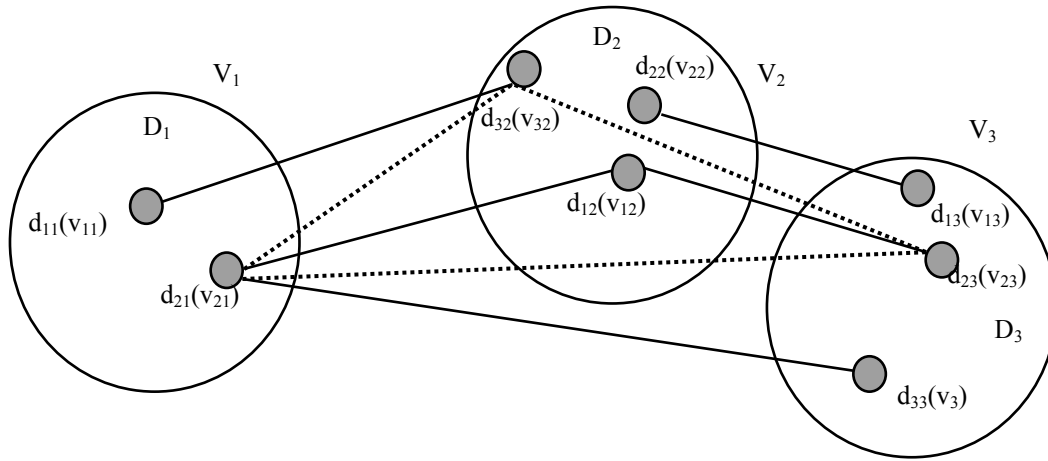|		
$V_1 = 20$	$V_2 = 30$	$V_3 = 50$
$v_{11} = 0.75$	$v_{12} = 0.50$	$v_{13} = 0.40$
$v_{21} = 0.25$	$v_{22} = 0.10$	$v_{23} = 0.30$
	$v_{32} = 0.40$	$v_{33} = 0.30$

Figure 2. Decision variant model (elementary decisions d_{21}, d_{32}, d_{23} connected with a dotted line) against a decision problem model (unbroken line – total contradiction; absence of a line or a dotted line means no contradiction) (*source: the authors*)

The relative significance weighting of a single decision Q is calculated as the sum of the products of the significance weightings of the decision areas and the significance weightings of the elementary decisions from their corresponding decision areas, using the formula:

$$Q = \sum V_i * v_{ji} \qquad (3)$$

where for each index i of the decision area D_i, the value of index j applies to the elementary decision d_{ji} from this area.

Significance weighting Q, on the example of the decision variant $<\{d_{21}\}\{d_{32}\}\{d_{23}\}>$, has the value:

$$Q = V_1 \times v_{21} + V_2 \times v_{32} + V_3 \times v_{23}$$
$$= 20 \times 0.25 + 30 \times 0.40 + 50 \times 0.30 = 32$$

In the example under consideration, there are seven possible decisions for which the weighting of the decision's significance may be calculated (see Table 1).

In table 1 the value $Q_{max} = 50$ was obtained as a result of adding up the partial values using the formula:

$$Q_{max} = V_1 \times (\max v_{j1} = 0.75) + V_2 \times (\max v_{j2}$$
$$= 0.50) + V_3 \times (\max v_{j3} = 0.40)$$
$$= 20 \times 0.75 + 30 \times 0.50 + 50 \times 0.40 = 50$$

Likewise the value $Q_{min} = 23$ was obtained by adding up the partial values using the formula:

$$Q_{min} = V_1 \times (\min v_{j1} = 0.25) + V_2 \times (\min v_{j2}$$
$$= 0.10) + V_3 \times (\min v_{j3} = 0.30)$$
$$= 20 \times 0.25 + 30 \times 0.10 + 50 \times 0.30 = 23$$

The weightings Q_{max} and Q_{min} are used in the procedure for decomposition of the solution tree of decision variants in the process of determining the strategy for searching for these variants. In the example in use, it turned out by chance that decisions 1 and 3 correspond to the calculated values of Q_{max} and Q_{min}. In general, correctly formed decision variants do not have to correspond to the threshold values due to the internal contradictions of elementary decision pairs.

Table 1. Significance weightings of decisions for the decision problem example in Fig. 2
(source: the authors)

Decision no.	Decision	Weighting of Decision Significance
1	$<\{d_{11}\}\{d_{12}\}\{d_{13}\}>$	$Q_{max} = Q_1 = 20 \times 0.75 + 30 \times 0.50 + 50 \times 0.40 = 50$
2	$<\{d_{11}\}\{d_{12}\}\{d_{33}\}>$	$Q_2 = 20 \times 0.75 + 30 \times 0.50 + 50 \times 0.30 = 45$
3	$<\{d_{21}\}\{d_{22}\}\{d_{23}\}>$	$Q_{min} = Q_3 = 20 \times 0.25 + 30 \times 0.10 + 50 \times 0.30 = 23$
4	$<\{d_{21}\}\{d_{32}\}\{d_{13}\}>$	$Q_4 = 20 \times 0.25 + 30 \times 0.40 + 50 \times 0.40 = 37$
5	$<\{d_{21}\}\{d_{32}\}\{d_{23}\}>$	$Q_5 = 20 \times 0.25 + 30 \times 0.40 + 50 \times 0.30 = 32$
6	$<\{d_{11}\}\{d_{22}\}\{d_{23}\}>$	$Q_6 = 20 \times 0.75 + 30 \times 0.10 + 50 \times 0.30 = 33$
7	$<\{d_{11}\}\{d_{22}\}\{d_{33}\}>$	$Q_7 = 20 \times 0.75 + 30 \times 0.10 + 50 \times 0.30 = 33$

6   Solution tree decomposition procedure

The procedure for generating decision variants is based on decomposition of the graph model of decision space. Decomposition involves the systematic extraction of Internally Stable Groups of Formative Sets (ISGFS), each fulfilling two conditions for being a decision variant (a decision):

- an ISGFS contains one elementary decision from each decision area (formative set),

- an ISGFS does not contain pairs of self-eliminating (alternative) decisions.

For example, for decision areas D_1, D_2, D_3 (see fig. 2), the sets $\{d_{11}, d_{22}, d_{33}\}$, $\{d_{11}, d_{12}, d_{13}\}$ and $\{d_{21}, d_{32}, d_{23}\}$ belonging to the set of acceptable decisions in the decision problem in question will be internally stable. Altogether we can identify 7 ISGFS variants in Fig. 2 (see Table 1).

The generation of decision variants (see Fig. 3) may proceed as follows:

(a)   the cardinality of each formative set is defined;

(b)   formative sets are put in descending order in regard to their cardinality values;

(c)   the formative sets of decisions belonging to all decision areas are split into as many groups of sets as the value of the cardinality of the most numerous formative set;

(d)   another vertex is added to the solution tree, along with the edges emerging from it, to which the respective groups of formative sets are assigned.

Various strategies may be applied for choosing a formative set, for example taking into account the significance V_i of a specific decision area in relation to the other areas, or the maximum number of edges connecting a particular set with the others; in the latter case, in the example used, the formative set corresponding to decision area D_2 would also be chosen.

The formative sets of the first vertex in the solution tree being constructed are equal to the sets of elementary decisions in the decision areas of the decision problem being resolved. These sets form the initial group of formative sets (GFS).

When creating successive GFS one has to remember that they should not contain decisions which are alternatives to the elementary decisions from the formative set in relation to which the GFS was split. If, as a result of the splitting, the cardinality of one of the formative sets in a GFS equals 0 – then this particular GFS is eliminated from the splitting process, and marked as an EGFS (Eliminated Group of Formative sets). If the cardinality of all formative sets in a particular GFS attains a value of 1 as a result of successive splits, then this group is a variant of an internally stable set of elementary decisions and is marked as ISGFS.

Formative sets are put in descending order according to their cardinality, in order to indicate the sets most suitable for effective decomposition of the solution tree (with the minimum number of splits).

Operations (a) to (d) are repeated until only groups marked as EGFS or ISGFS remain within the GFS of the solution tree undergoing decomposition. Groups marked as ISGFS constitute a set of all possible decision variants such that no variant contains a pair of alternative decisions.

In the procedure for decomposing the solution tree a significant role is played by the cardinality of the formative set according to which in a specific vertex the decision problem described by the collection of formative sets ascribed to this vertex is to be decomposed. The operation of decomposing one of the formative sets is accompanied by the operation of the unfolding of the current vertex into a set of vertices equal in number to this set's cardinality (see Fig. 3 and Table 3). Intuition (heuristics) suggests that the most numerous formative set, from the collection of formative sets assigned to the vertex in question, should be subjected to decomposition. A strategy preferring decomposition according to the formative set (decision area) whose elementary decisions display the most numerous conflicts (contradictions) with the elementary decisions of the remaining decision areas may be equally as justified (in the example we are using, this is decision area D_2).

The execution of operations (a) to (d) is illustrated by Fig. 3 and Table 2. The ISGFS decision variants on the solution tree are marked in grey. EGFS (position 11 in Table 3) signifies an eliminated decision due to it lacking elementary decision d_{21}.

The procedure for decomposing the solution tree explicitly defines the proceedings which should be carried out in order to obtain the decision variants (tuples of elementary decisions).
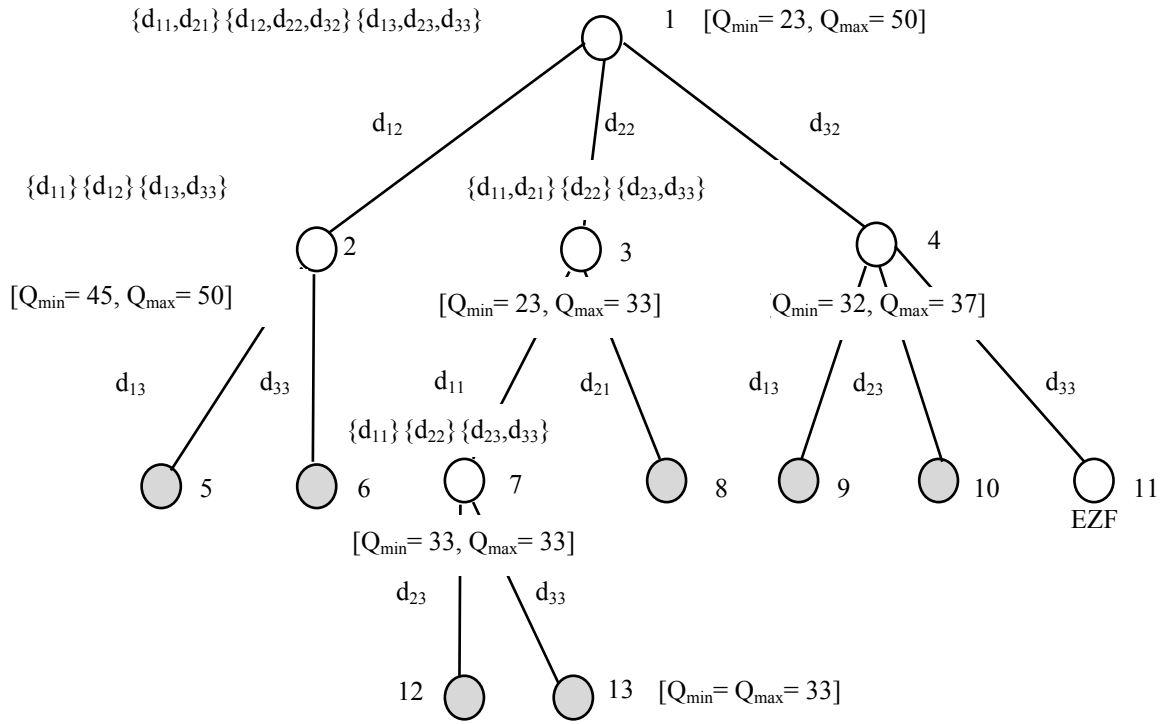
Figure 3. Solution Tree
(*source: the authors*)

Table 3. Vertices, formative sets, and ISGFS solutions of the decomposition tree for the decision problem; the symbol → indicates tree vertices occurring after the current vertex
(source: the authors)

Vertex no.	Formative sets	Q_{min}	Q_{max}	ISGFS solutions	For decomposing
1→2,3,4	$\{d_{11},d_{21}\} \{d_{12},d_{22},d_{32}\} \{d_{13},d_{23},d_{33}\}$	23	50		$\{d_{12},d_{22},d_{32}\}$
2→5,6	$\{d_{11}\} \{d_{12}\} \{d_{13},d_{33}\}$	45	50		$\{d_{13},d_{33}\}$
3→7,8	$\{d_{11},d_{21}\} \{d_{22}\} \{d_{23},d_{33}\}$	23	33		$\{d_{11},d_{21}\}$
4→9,10.11	$\{d_{21}\} \{d_{32}\} \{d_{13},d_{23}\}$	32	37		$\{d_{13},d_{23}\}$
5	$\{d_{11}\} \{d_{12}\} \{d_{13}\}$	50	50	$<d_{11},d_{12},d_{13}>$	ISGFS
6	$\{d_{11}\} \{d_{12}\} \{d_{33}\}$	45	45	$<d_{11},d_{12},d_{33}>$	ISGFS
7→12,13	$\{d_{11}\} \{d_{22}\} \{d_{23},d_{33}\}$	33	33		$\{d_{23},d_{33}\}$
8	$\{d_{21}\} \{d_{22}\} \{d_{23}\}$	23	23	$<d_{21},d_{22},d_{23}>$	ISGFS
9	$\{d_{21}\} \{d_{32}\} \{d_{13}\}$	37	37	$<d_{21},d_{32},d_{13}>$	ISGFS
10	$\{d_{21}\} \{d_{32}\} \{d_{23}\}$	32	32	$<d_{21},d_{32},d_{23}>$	ISGFS
11	$\{\phi\} \{d_{32}\} \{d_{33}\}$	-	-	$< \phi, d_{32},d_{23}>$	EGFS
12	$\{d_{11}\} \{d_{22}\} \{d_{23}\}$	33	33	$<d_{11},d_{22},d_{23}>$	ISGFS
13	$\{d_{11}\} \{d_{22}\} \{d_{33}\}$	33	33	$<d_{11},d_{22},d_{33}>$	ISGFS

During the decomposition of successive decision tree vertices, different strategies for decomposing the formative sets may be applied. They may take different criteria into account (e.g. the cardinality of formative sets, the significance of decision areas, or the value of internal stresses between elementary decisions of different decision areas).

In the process of decomposing a solution tree's vertices, in each vertex unfolded (subjected to decomposition) it is important to assess the anticipated maximum

Q_{max} and minimum Q_{min} significance weightings of the decisions which might be obtained as a result of this vertex's decomposition. In successive vertices subjected to decomposition, on the tree shown in Fig. 3, the current GFS was taken into account (see Table 3) for calculating the Q_{max} and Q_{min}.

The valuation of decisions when decomposing a solution tree's vertices leads to the determining for each newly-created vertex its potential minimum and maximum significance weightings. The term "potential" expresses respectively the lower and upper thresholds of the expected significance weighting of the decision, which due to possible contradictions # (see chapter 7) will not be possible to achieve (such a case does not occur in the example being used). For example, in Fig. 3, vertex no. 3 has a calculated span [Q_{min} = 23, Q_{max} = 33] which decisions (vertices) nos. 8 [Q = 23], 12 [Q = 33] and 13 [Q = 33] correspond to. Early determining of the thresholds Q of potentially anticipated decisions leads to a significant narrowing of the search for decisions fulfilling a defined scope. However, one must bear in mind that due to eliminated elementary decisions also having a part in the calculations it may turn out that the chosen search direction leads us to an empty decision set.

7 Flat decision problems with internal contradictions

Elementary decisions belonging to different decision areas (see fig. 4) may be in a relation of contradiction $\#(d_{kp}, d_{jq})$ with one another, which in the figure is marked with an unbroken line connecting a specific pair of elementary decisions (where # = 1 means total contradiction, which does not allow for the simultaneous occurrence of both elementary decisions in a single decision variant) or dashed line (where 1 > # > 0 means a partial contradiction, which may occur in a decision if appropriately implemented, which is most often related to an increase in the costs of executing such a decision). A value of # = 0 means there is no contradiction, or in other words the cost-free simultaneous presence of both elementary decisions in the decision variant is possible. Contradictions $\#(d_{kp}, d_{jq})$, characteristic of relations occurring between pairs of elementary decisions, can also cause positive effects occurring as a result of positive synergy in the decision areas p, q.

The simultaneous contradiction occurring between m elementary decisions (m-contradiction) belonging to different decision areas is calculated as the sum of the averaged contradictions occurring between each pair of elementary decisions forming a particular m-contradiction, in keeping with the definition:

$$\#<d_{j1}, d_{j2}, ..., d_{jm}> = \sum \#<d_{jp}, d_{jq}> \qquad (4)$$

$$\#<d_{jp}, d_{jq}> = [\#(d_{jp}, d_{jq}) / (1 - \#(d_{jp}, d_{jq}))] \times [(v_{jp} \times V_p + v_{jq} \times V_q) / (V_p + V_q)] \qquad (5)$$

where:
p = 1..(q-1); q = 2..m,
$\#(d_{jp}, d_{jq})$ - the value of the contradiction (stress) between elementary decisions d_{jp}, d_{jq} measured on a scale [0..1].

The example below, together with Fig. 4, constitutes an illustration of the calculations for valuation of decisions taking internal stresses into account.

Calculations for the internal contradiction for decision no. 5 $\#<d_{21}, d_{32}, d_{23}>$ proceed as follows:

$\#<d_{21}, d_{32}, d_{23}>$
     $= \#<d_{21}, d_{32}> + \#<d_{21}, d_{23}> + \#<d_{32}, d_{23}>$

$\#(d_{21}, d_{32}) = 0.20$
$\#<d_{21}, d_{32}> = [\#(d_{21}, d_{32}) / (1 - \#(d_{21}, d_{32}))] \times [(v_{21} \times V_1 + v_{32} \times V_2) / (V_1 + V_2)]$
     $= [0.20 / (1 - 0.20)] \times [(0.25 \times 20 + 0.40 \times 30) (20 + 30)]$
     $= [0.25] \times [(17) / (50)] = 0.25 \times 0.34 = 0.085$

$\#(d_{21}, d_{23}) = 0.10$
$\#<d_{21}, d_{23}> = [\#(d_{21}, d_{23}) / (1 - \#(d_{21}, d_{23}))] \times [(v_{21} \times V_1 + v_{23} \times V_3) / (V_1 + V_3)] = [0.10 / (1 - 0.10)]$
     $\times [(0.25 \times 20 + 0.30 \times 50) / (20 + 50)]$
     $= [0.11] \times [(20) / (70)] = 0.11 \times 0.29 = 0.032$

$\#(d_{32}, d_{23}) = 0.15$

$\#<d_{32}, d_{23}> = \#(d_{32}, d_{23}) / (1 - \#(d_{32}, d_{23})) \times [(v_{32} \times V_2 + v_{23} \times V_3) / (V_2 + V_3)] = [0.15 / (1 - 0.15)]$
     $\times [(0.40 \times 30 + 0.30 \times 50) / (30 + 50)]$
     $= [0.18] \times [(27) / (78)] = 0.18 \times 0.35 = 0.063$

$\#<d_{21}, d_{32}, d_{23}> = \#<d_{21}, d_{32}> + \#<d_{21}, d_{23}> + \#<d_{32}, d_{23}> = 0.085 + 0.032 + 0.063 = 0.180$

The value of Q for contradiction # > 0 is calculated using the formula:

$$Q^{\#} = Q \times (1 + \# \{ d_{j1}, d_{j2},... d_{jm} \}) \qquad (6)$$

In the case of decision no. 5, the value of $Q^{\#}$ calculated when taking into account the internal contradictions of the elementary decisions is:

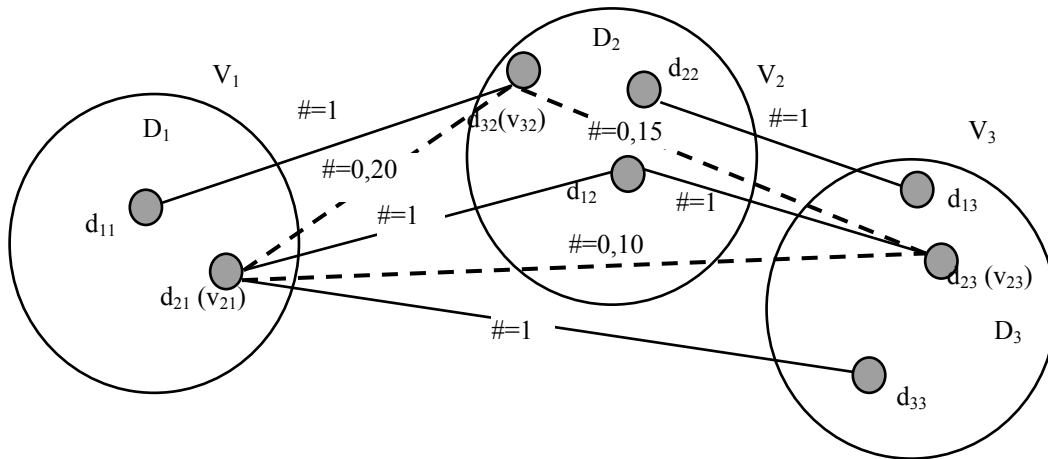$$Q_5^{\#} = 32 \times (1 + 0.180) = 37.76$$

Figure 4. Decision variant model (connections between elementary decisions d_{21}, d_{32}, d_{23} highlighted with a dashed line) against the decision problem model (unbroken line # = 1 – total contradiction; dashed line contradictions within the range [0.10..0.20]; no line # = 0 – no contradiction) (*source: the authors*)

Table 4. Comparison of decision significance weightings for the decision problem example in Fig. 4 taking internal contradictions into account; the table does not give the results $Q^{\#}$ for decisions 3 and 4; grey is used to mark elementary decisions which are in contradictions #; the symbol ↑ marks an expected growth in the decision's significance weighting (*source: the authors*)

Decision no.	Decision	Q	$Q^{\#}$
1	<{d_{11}} {d_{12}} {d_{13}}>	50	50,00
2	<{d_{11}} {d_{12}} {d_{33}}>	45	45,00
3	<{d_{21}} {d_{22}} {d_{23}}>	23	23↑
4	<{d_{21}} {d_{32}} {d_{13}}>	37	37↑
5*	<{d_{21}} {d_{32}} {d_{23}}>	32	37,76
6	<{d_{11}} {d_{22}} {d_{23}}>	33	33,00
7	<{d_{11}} {d_{22}} {d_{33}}>	33	33,00

A comparison of values Q and $Q^{\#}$ calculated for the individual decisions makes it possible to choose the most favourable option (see Table 4). An increase in the value of $Q^{\#}$ was noted for decisions 3, 4 and 5, because they contain internal contradictions #.

8 Hierarchical Decision Problems

In general the essence of a decision process is the taking and execution of decisions in an hierarchical system, at the base of which are operational decisions resolved in flat decision problems (their decision areas and elementary decisions are known). At the tactical and strategic levels intermediate tasks are tackled and resolved.

Strategic, tactical and operational decision problems, and the tasks constituting their solution, belong to defined organisational structures and the competences of their members. In other words, hierarchical decision

problems are "fastened" to organisational structures in the form of a "competence grid", which causes collisions in the decisions of their accompanying executive processes and the jamming of essential resources (projects). In this situation it is important to have available methodology enabling the coordinated addressing (steering) of decision problems and their resultant tasks for carrying out within the right cells and at the appropriate levels (rungs) of the organisational structure.

The decision-taking process in an hierarchical system is a process conditioned by context: in the superior layer, at the level of the organisation's board of management, decisions depend on business strategy currently being applied, verified by the supervisory board, and on the general state of execution of tasks in intermediate layers and in the operational layer. The taking of decisions in the intermediate layers is determined by the results in the lower layers and the planning decisions of the higher layers.
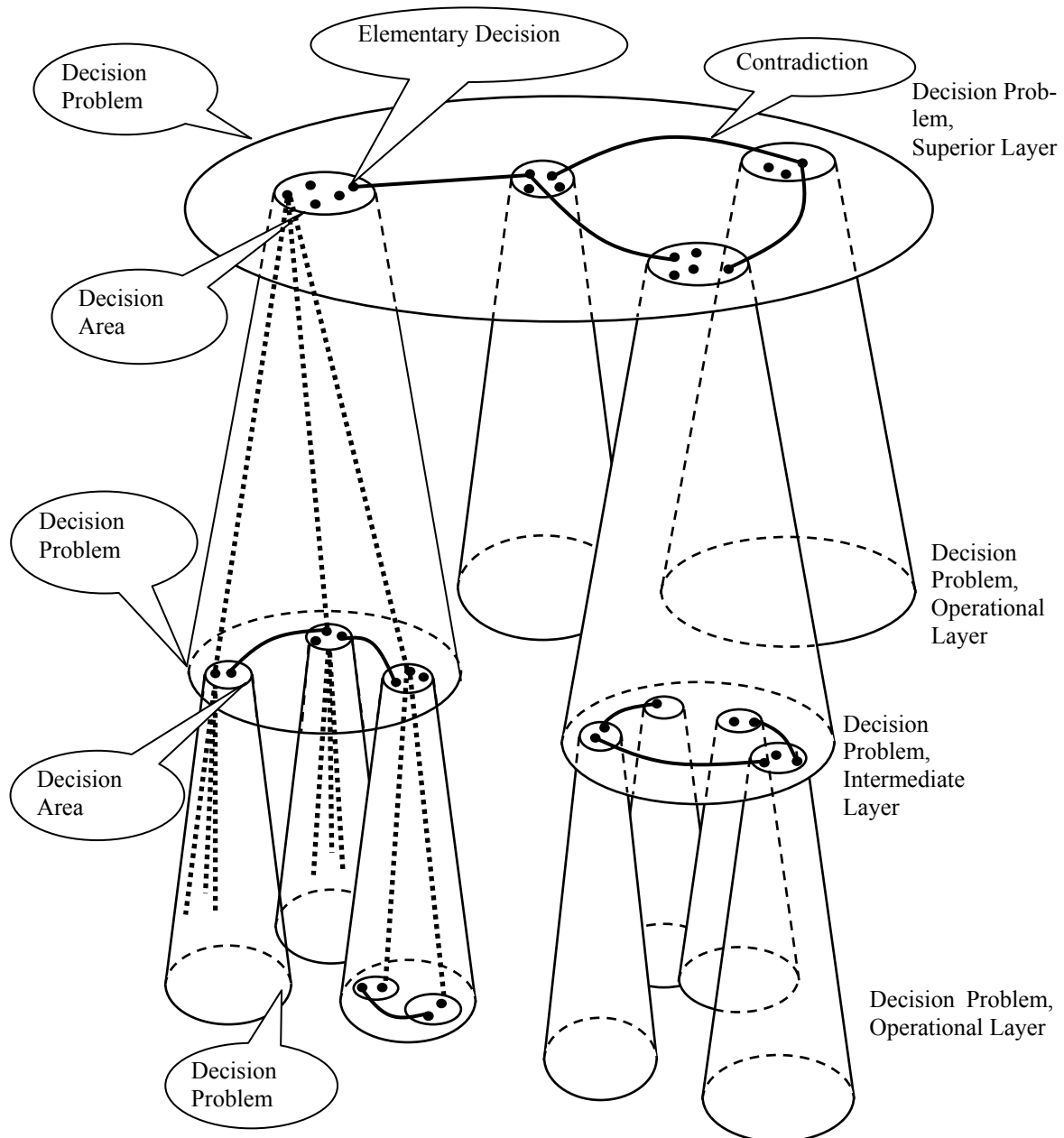
Figure. 5. Decision Problem Model in a Hierarchical System
(*source: the authors*)

In the operational layer the decision-taking is limited by the determinism of its decision areas. A significant parameter of the decision processes is time and the related necessity to keep pace with the coordination of decisions.

The cardinal rule in the construction of hierarchical decision systems (HDS) is to ascribe to each decision area in a higher level a decision problem linked directly to it, the solutions (decisions) of which become the elementary decisions of the decision area in question.

In general, decisions in HDS are taken at a few levels (layers) simultaneously, based on the situation which has arisen in the neighbouring layers. The process of designing and taking decisions depends in such a case on the character of the organisation – although decisions in higher layers are always shaped on the basis of the state of execution of tasks in the lower layers – and symmetrically the tasks in the lower layers are formulated on the basis of the plans and their resultant decisions in the upper layers. We can therefore observe two opposite streams: a decision stream ("top to bottom") and an information stream, about the state

of task execution ("bottom to top"). Tasks corresponding to the elementary decisions are carried out and decision-taking processes (processes of associating elementary decisions belonging to different decision areas) take place on each of these layers. Fig. 5 illustrates the mutual positioning of decision problems on the superior (strategic), intermediate (tactical) and operational layers. It is easy to notice that the decision area (containing elementary decisions) of a higher layer becomes the decision problem of the layer positioned directly below.

In a hypothetical 3-level hierarchical system the generation of decision variants is a two-phase process, repeated iteratively, which involves:

- in the first phase:
  - definition of the decision problem and its decision areas, as well as the significance weightings of these areas, on the level of the strategic layer (see Fig. 5),
  - on the level of the tactical layer: the decision problem and its decision areas, as well as the significance weightings of these areas, are defined for each decision area from the strategic layer,
  - on the level of the operational layer: the decision problem and its decision areas, as well as the significance weightings of these areas, are defined for each decision area from the tactical layer,
- in the second phase:
  - on the level of the operational layer: for each decision problem and its decision areas, elementary decisions are defined and pairs of contradictory decisions belonging to different decision areas of the same decision problem are marked, and the weightings of these areas' elementary decisions are determined; the weightings of the elementary decisions of the operational layer are determined irrespective of the significance weightings of the superior layers, and this is an apriori process,
  - on the level of the tactical layer: for each decision problem and its decision areas, elementary decisions are defined with the help of the decomposition procedures of decision trees corresponding to the decision problems of the operational layer, and pairs of contradictory decisions belonging to different decision areas of the same decision problem are marked in the

tactical layer (as in the case of a flat decision problem) and the weightings of these areas' elementary decisions are determined; the weightings of the elementary decisions of the tactical layer are determined as a result of calculation of the value of the operational level's decision corresponding to a specific elementary decision in the tactical level; this procedure occurs irrespectively of the significance weightings of the superior layers and is apriori in character in relation to the strategic layer,

  - on the level of the strategic layer – as for the tactical layer – for each decision problem and its decision areas, elementary decisions are defined with the help of the decomposition procedures of decision trees (see fig. 5) corresponding to the decision problems of the intermediate layer, and pairs of mutually contradictory decisions belonging to different decision areas of the same decision problem (as in the case of a flat decision problem) are marked in the layer above, and the weightings of these areas' elementary decisions are determined; the weightings of the elementary decisions of the strategic layer are determined as a result of calculation of the value of the tactical level's decision corresponding to a specific elementary decision in the strategic level,
  - above the level of the strategic layer: the decision area comprising the elementary decisions obtained through the decomposition procedure for the decision tree corresponding to the decision problem of the strategic layer is defined, and the elementary decisions of this area are determined; the decision is taken by indicating one of the elementary decisions obtained as a result of decomposition of the decision tree for the strategic layer; taking a decision at the strategic level implies the explicit indication of decisions at all other levels and in all of their decision problems.

Fig. 5 shows with dotted lines how an elementary decision from a superior level (e.g. strategic) is connected to the decision problems and elementary decisions from an intermediate (tactical) or the operational layer.

If the results obtained are for certain reasons dissatisfactory, there may be change in the share of the significance weightings of the decision areas in certain decision problems.
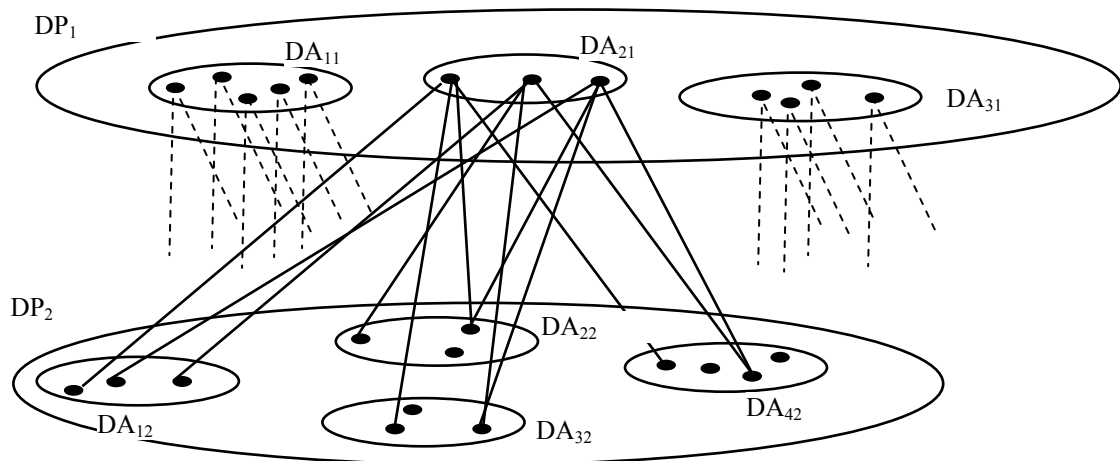
Figure 6. Example of two decision problems in an hierarchical system: DP_1 – superior decision problem, DP_2 – subordinate decision problem (*source: the authors*)

One can also successfully look for decisions whose assessment is situated within limits set in advance, as occurs in the case of flat decision problems.

In the case of settling (resolving) hierarchical decision problems, we are dealing with two types of decision: related to projects and to management, and taken in specific layers of the decision problem model (see Fig. 4 and Fig. 5).

A management decision – within the process guidelines – determines in a specific decision problem alternative variants of processes for the consolidation and/or functioning of structural elements of the object being designed, elements which the design team recommends as acceptable problem solutions. The set of these acceptable solutions becomes a set of elementary decisions for the decision area belonging to the immediately superior decision problem of the design proceedings underway. The same situation occurs in the case of project decisions.

A project decision – within the technical guidelines – determines in a specific decision problem alternative variants of elements which the design team recommend as acceptable solutions for this problem. The set of these acceptable solutions becomes the set of elementary decisions for the decision area belonging to the immediately superior decision problem of the design proceedings underway.

The hierarchical decision problem presented in Fig. 6 features the following properties:

- there are at least two such decision problems (see DP_1 and DP_2), in the first of which there is at least one decision area (see DA_{21}) ensuing as a result of the solving of the second decision problem,

- different scopes of competence among the decision-takers responsible for these problems correspond to different decision problems, in such a manner that the elementary decisions of decision areas belonging to a single decision problem (e.g. decision areas DA_{12}, DA_{22}, DA_{32} and DA_{42} of decision problem DP_2) do not concur, and the decision areas of different decision problems linked directly to one another do not concur; however, the existence of common decision areas for different decision problems not directly linked to one another is permitted (e.g. DA_{22} and DA_{23}, see Fig. 7),

- four decision areas of the subordinate layer's decision problem (in the example used these four areas are: DA_{12}, DA_{22} and $DA_{13} = DA_{23}$) correspond to all the elementary decisions belonging to one decision area of the superior layer's decision problem (e.g. to two elementary decisions from decision area DA_{21} of decision problem DP_1).

Hierarchical decision problems are widespread, and we deal with them in:

- the planning and management of projects, and the designing of complex organisational-technical and business undertakings, such as exchanges and banks,

- the designing of technical objects – such as machinery and complicated technical equipment, such as aircraft, spacecraft and ships,

- the designing of complex property investments such as intelligent buildings and other construction investments, bridges, roads and motorways, and retail chains,

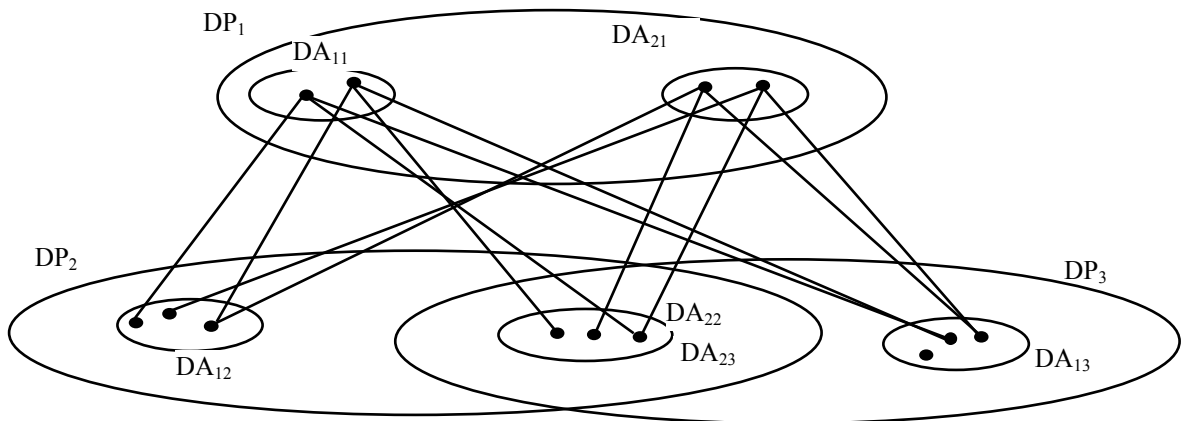- military and aerospace applications.

Figure. 7. An example of three decision problems in an hierarchical system: DP_1 – superior decision problem, DP_2, DP_3 – subordinate decision problems with a common decision area marked with two identifiers: DA_{22} and DA_{23}
(*source: the authors*)

9   Practical applications

In a world of rapidly developing informational technologies, the process of taking decisions cannot remain purely intuitive. Artificial intelligence, expert systems, data warehouses and evolutionary programming – these are only examples of the more important activities being carried out with the objective of reinforcing the intellectual and procedural capabilities of mankind. Laying bare the essence of the decision process is not easy – although models of elementary decision acts or more complex decision processes carried out using Decision Support Systems (DSS) seem to be within reach.

We most often understand DSS as methodological and computer solutions which prove useful in those decision situations and problems for which there are no explicit procedures leading to a solution which is correct and effective in all respects.

It was almost half a century ago that researcher at Stanford University developed the first ever expert system, DENDRAL, in 1965. The basic task of the system was to determine the molecular structure of organic compounds based on the analysis of their electromagnetic spectrums. The 1990s saw beginning of the rapid development of the data warehousing technology and OnLine Analytical Processing (OLAP). As a result of advanced methods of artificial intelligence (evolutionary algorithms and neuroidal networks) and the stormy growth in information technologies, semiotic data models are considered above all to be the leading models in decision processes.

As an advanced method of structural and functional research, the AIDA technique may serve as an example of an advanced use of semiotic analyses in at least two different aspects of decision making:

- generating permissible elements in decision space structure D,
- generating the trajectories of a system's functional states in decision space D.The first case, using the AIDA technique, involves the process of decomposing decision areas down to decision variants, from among which the ultimate choice is made. In the second, the AIDA technique serves the "rapid" generation of decision variants interpreted as discrete states of a dynamic system.

The processes of generating the elements and trajectories in space D should be assessed quantitatively and qualitatively. A promising application of the AIDA technique is its usage in situations of large and complex decision spaces, i.e. everywhere where the moment of taking the decision should be preceded by a simulative phase of generating all or "almost all" decision variants.

In certain practical applications one should also count on the AIDA technique – due to the limited time for taking the decision or significant costs of elaborating the decision variants – proving effective in the steered preparation of a significant number of decision variants, among which there should be the locally optimal sub-sets of the variants searched for (this applies in particular to steering tasks in conditions where the variability of a system's parameters is highly dynamic).

Searching for methods of iterative balancing of global (hierarchical) decisions, based on the valuation of flat decisions' significance taking into account the strength of their locally predefined contradictions, invariable remains a long-term direction for research for the example of hierarchical decision problems.

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SMART GRIDS IN THE PROCESS OF BUILDING A COMPETITIVE ECONOMY AND ENERGY SECURITY IN EUROPE

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Abstract: Article aims to present the technological innovation - Smart Grids in the process of maintaining Europ's energy security, competitiveness of economy and environmental protection. Innovative intelligent networks are the solution to accelerate the liberalization process of the energy sector, and also to grow energy efficiency and savings in the consumption of electricity. Management of energy production and efficient planning of consumption will bring benefits for the economic development. Technology of smart grids will change in the future the structure of the supply of energy towards a decentralization system. This article consist of three main parts, the first concerns the analysis of energy policy in Europe with the most significant factors that shape this policy, the seconde part concerns the presentation of the smart grids solutions essence for electricity and the benefits generated by the process of implementing in the energy system. The third part is devoted to European and Polish projects in the subject of smart meters.

Keywords: energy innovations, energy technologies, energy policy, competitive economy.

1   Introduction

Smart Grid in contemporary Europe and the world economy is an innovation and challenge, which allows people in the future to gain a stable position on energy, economic and environmental protection.

Due to the importance of this issue, I think that there is a great need to take this subject in a public forum, because in many countries there is the lack of knowledge on this topic, which also is confirmed on social evidence.

Innovative intelligent network in power industry and in the entire economy is now essential to energy safety, effective management of limited resources and it provides economic development of the country.

My primary purpose in this article is to justify the introduction of intelligent networks, together with the presentation of the essence of the smart grids action and also to present some of the projects on a European scale, in which Poland has some part or is an independent executor.

2   Key factors affecting energy policy in Europe

European energy policy, which is reflected by climate and energy package 20-20-20 is to introduce in the European Union so called "Green revolution" both in industry and energy, but in particular it has to lead to a move away from high emission coal for renewable energy and energy efficiency. The basic assumptions of the package proposed by the European Commission in January 2008 are:

- reduction in CO2 emission by 20% in 2020 in comparison with 1990,
- increased use of renewable energy in the EU from the present 8.5% to 20% in 2020, for Poland the growth was adopted from 7 to 15%,
- the increase of energy efficiency in 2020 by 20%.

In particular way, it should be emphasized that the increase in energy efficiency has a significant impact on reducing CO2 emissions and also to increase renewable energy in the structure of energy production.

The reasons for this energy policy are rooted in the existing energy resources in Europe and the world, in the prices of fuels, the consumption of energy and environmental protection.

It is therefore important to provide some economic indicators that will allow the characterization of the current energy situation in Europe, as well as trends in the behavior of these quantities in the future.
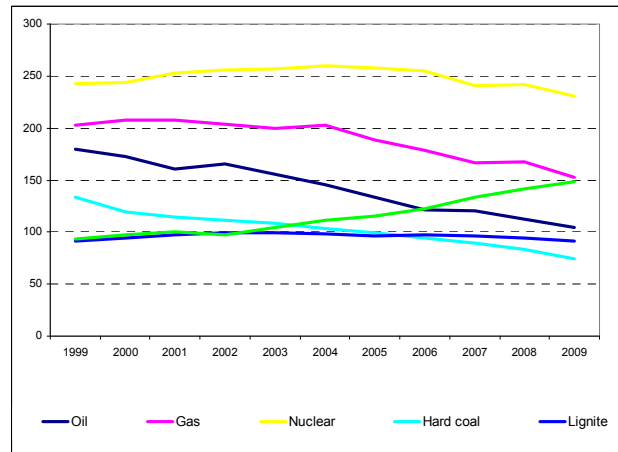
Figure 1. Production of primary energy sources in the years 1999 - 2009
(*source: Energy, transport and environment indicators. Eurostat 2011*)
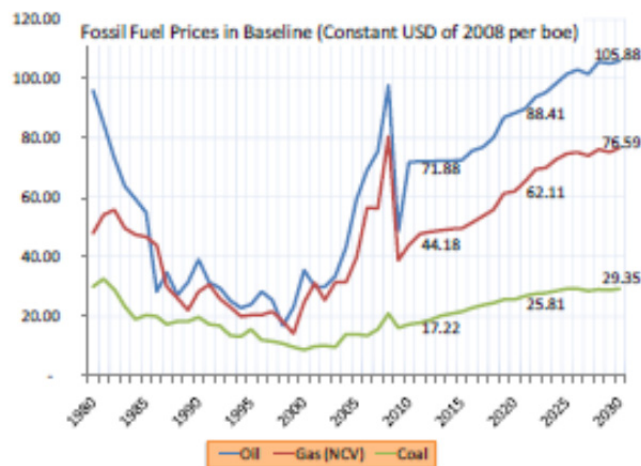
Figure 2. World fossil fuel prices
(*source: EU Energy Trends to 2030 - update 2009, European Commission, 2010*)

The Fig. 1 shows that the countries of the European Union in the period 1999-2009 recorded a downward trend (that is 14%) in the extraction of primary energy sources, especially the fact existed between 2008 and 2009. Production of nuclear energy is the highest in the EU in relation to fossil fuels which is largely due to French and German energy potential. On the other hand, it is important phenomenon that a significant increase in the share of production from renewable energy sources (RES) has been in the last decade - 60%.

The dependence of Europe in the subject of energy is on the level of 53,9%, which represents the largest share of petroleum imports (mainly from Russia and Norway), and it must be emphasized that there is great demand for this raw material in the economies of the EU. The important information is that the total energy consumption in the world has increased 37,3% since 1990 where the highest consumption exist in the U.S., EU and China. The U.S. and EU economies are mainly based on oil consumption, while China's economy on fossil fuels.

The prices of fossil fuels have increased significantly in the last decade, and they will grow steadily to 2030. (see Fig. 2) It is worth emphasizing that the oil will have the highest price, and about 38% lower price gas will have, and the lowest price is to be expected for carbon that is by 60% compared to the price of oil as shown in the graph (see Fig. 2).

Efficient use of produced energy has improved significantly in the processes of economic activity in the last decade (14%) and is located in 2009 at 812 Mtoe (in 1999. level was - 949 Mtoe).
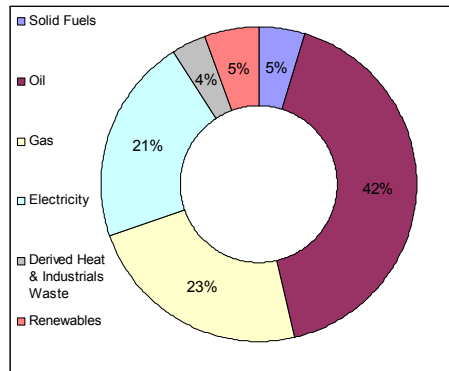
Figure 3. Final Energy Consumption - 27th EU
(*source: EU Energy and Transport in Figures, European Commission, Statistical Pocketbook, 20*10)
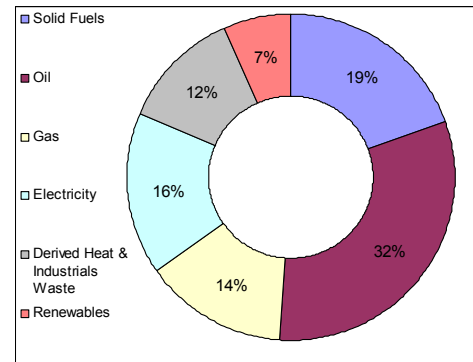
Figure 4. Final Energy Consumption - Poland
(*source: EU Energy and Transport in Figures, European Commission, Statistical Pocketbook, 2010*)
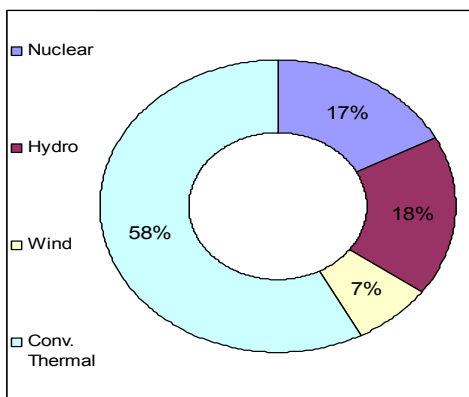
Figure 5. Electricity Production Capacity - EU-27
(in GW)
(*source: EU Energy and Transport in Figures, European Commission, Statistical Pocketbook, 2010*)
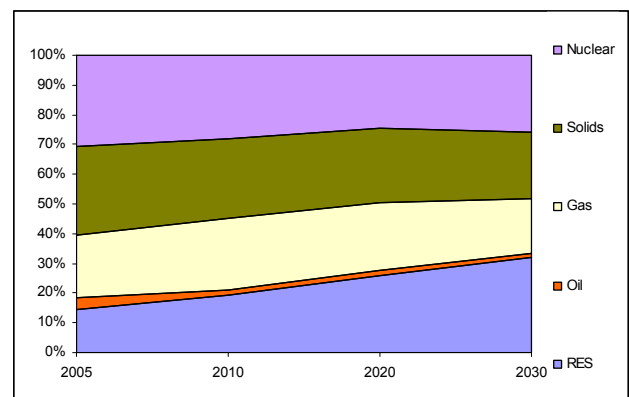
Figure 6. Gross Power Generation by Source by 2030
(*source: EU Energy Trends to 2030 - update 2009, European Commission, 2010*)

This phenomenon is a result of new, innovative technologies for better use of available energy sources.

These considerations lead to the finding that if the extraction of fossil fuels in Europe has decreased, and the economies of the European Union are based largely on the use of oil (and also gas in the second place), the basic conclusion is that in the near future, the EU economy significantly reduce their competitiveness in relation to the rest of the world, despite increasing energy efficiency.

However the further policies of energy dependence of the European Union will lead to increased economic risk, political and energy danger.

In addition, electrical power is a 21% share in the structure of the total energy consumption of European Union countries (see Fig. 3) and in Poland it is a level of 16% (see Fig. 4).

Electricity production in the EU comes mainly from conventional sources – 57,7% and nuclear power – 17,1% remaining sources of RSE – 25,2%.

Conventional energy resources (coal, oil, gas) for electricity production dominate at a high degree in Germany, Great Britain, France, Italy and Poland. Nuclear energy is essential for the production of electricity, in France and Germany particularly, renewable energy (hydro power) in Sweden, wind power and solar power in Spain and in Italy - mainly hydro power. In the years 1990 - 2007 in Europe, the production of wind energy was reported with the largest increase. Renewable energy sources in the structure of electricity generation in recent years are rising to a considerable extent. A similar trend is also projected to 2030 (see Fig. 6). In addition, there is a decrease share of gas by 5,2% compared to 2010, 4,7% share of fossil fuels and 2,1% share of nuclear energy.
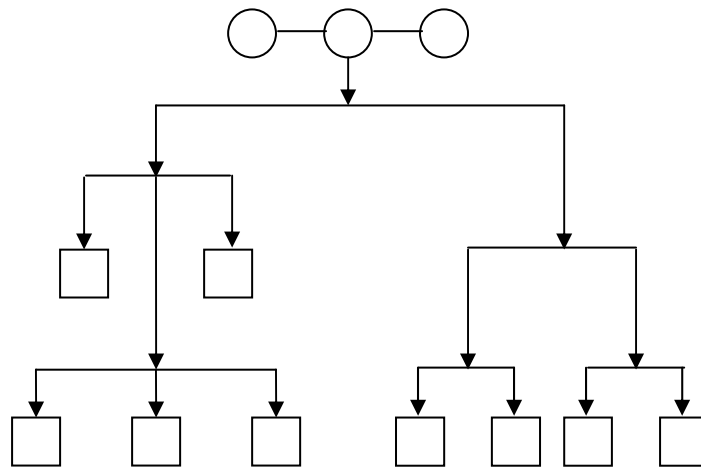
Figure 7. Diagram of the conventional power grids
(*source: own elaboration*)

Conventional sources are projected to gradually decline (gas, coal and oil) in the production of electricity. This fact is due to the EU energy policy mainly, environmental and economic considerations and significant increase in the prices of these fuels as a result of changes in supply and a gradual decline in the rate of economic growth in Europe.

3 Smart grid as the essence of innovative technology growth of the efficiency and competitiveness of the european economy

In the energy policy of the European Union, electricity production sector holds an important place, because it has a growing role in the economy and affects the quality of life. One of the fundamental problems of economic development is to meet rapidly growing demands for electricity, whose production is more and more expensive and still harmful to the environment, and what is more the European Union countries are increasingly dependent on imported energy resources.

Therefore, it is necessary to expand production capacity, modernize aging energy infrastructure and transmission infrastructure while taking into account environmental protection. All these elements impact on the system's energy security.

The solution of these problems requires intensified actions that can be implemented in the traditional or innovative form. Classical solutions previously used in the construction of power units, and energy networks requires high capital and time. So essential is now a new way to support energy security, based on innovative technologies that allow more efficient use of energy resources, better management of them, and introduction of new forms of energy sources for electricity generation.

The implementation of these challenges requires a flexible network and "thinking" infrastructure that will provide energy exactly where there is demand, so called - smart grid.

3.1 Nature and potential of innovation in the smart grid

In the literature concerning smart grid it is difficult to find a clear definition of the term above. Therefore, to clarify the idea of such innovation will consist in presentation of the basic characteristics associated with its operation

Electrical energy has a growing importance in the European economy and the world. A characteristic feature of the modern world is the digitization of many economic sectors and spheres of society, which began with the creation of mobile Internet and fast communication and remote control.

Therefore, the existing electricity networks also require specific changes to adapt to the digital environment.

The current operation of power transmission systems is to use large power plants in the hierarchical, one-way system, that is from the generator of electricity through transmission and distribution network to the final customer (see Fig. 7). The main weakness of the structure is too long way transmission of electricity to the end-user which causes numerous threats on route of transportation.
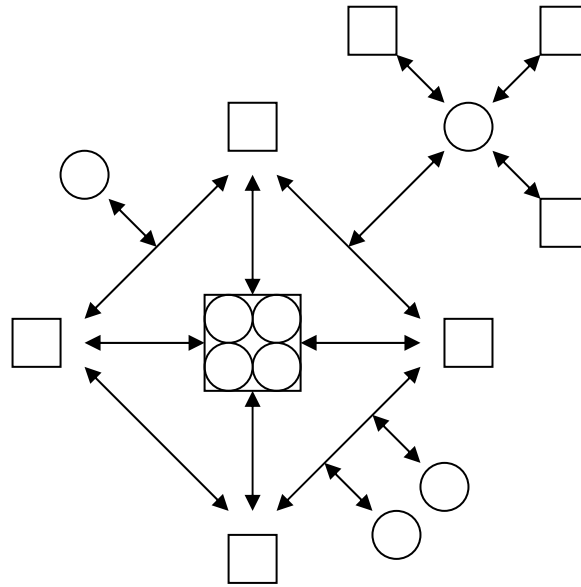
Figure 8. Diagram of smart energy networks - Smart Grids
(*source: own elaboration*)

In addition, instability in the power supply throw lack of continuity of the quality parameters cause currently great economic damage in the production processes of enterprises.

Modern digital economy requires a smart grid that will comply with the following features (according to the U.S. Department of Energy agreed in June 2009):

- optimising the use of energy resources, and operational efficiency,
- use of all technology solutions for energy generation and storage,
- assurance of quality supply for all needs of the digital economy,
- prediction of disturbance in the system and respond to self-repair mode,
- having resistance to physical and cyber attacks and natural disasters,
- enabling active participation of customers,
- enabling the introduction of new products, services and markets[1].

For these functions system must have a network structure with two-way communication where you can make the implementation of innovative technologies to increase economic efficiency and technical support (see Fig. 8).

Smart Grid is not an end in itself but a response to technical and economic level, against the challenges that the power sector is confronting in Europe and worldwide.

This Table 1 presents the main characteristics of intelligent energy networks which will be the future of the whole energy system of the world and Europe. An important difference compared to the previous hierarchical grids is that they are digitally controlled and have a network architecture which enables interaction between customers and the market.

The plans of introducing this kind of the power system will also bring many benefits to a number of entities operating in the energy industry. The Operators will have improved ability to monitor and control network, which will enable them to provide a higher level of system reliability. Distribution companies will have lower distribution losses, delay capital expenditures and reduced maintenance costs. Recipients will gain a greater impact on energy costs, including the possibility of self-power generation, while the benefits of more reliable energy supply. Moreover, the environment will benefit by reducing peak demand, the spread of renewable energy sources and related reduction in CO_2 emissions and other pollutants.

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[1] Feliachi A., Saymansky J., Choudhry M., Sneckenberger J. - *Are All Smart Grids Equal?* Journal of Electrical Systems, 2011.

Table 1. Comparative characteristics of the traditional electric power system with the Smart Grid network
(*source: Malko J. - Why do the networks have to be smart?, Wulkan, 1(18) 2011*)

	Hierarchical Network (Traditional)	Smart Network
Steering, control, metering	electromechanical	digital
Communication, information flow	one-way	bidirectional
Generation	centralized	distributed
Architecture	hierarchical	network
Sensors	a few	universal
Transparency structure	untransparent	own monitoring
Disaster recovery activities, failures, black-outs	manually corrected	self-correcting
Inspection / Testing	manual	remote
Communication with customer	limited	all-encompassing
Chance of selection by the user	low	many choices

According to the U.S. research institute EPRI (Electric Power Research Institute), the investment in the development of smart grid technologies and their implementation in the U.S. in the amount of 165 billion. $ bring revenues from 638 to 802 billion dollars. This means the factor income / expense in the amount of from 4:1 to 5:1[2].

3.2 The conditions, which necessitate introduction of intelligent energy

3.2.1 Climate change

In the years 2004-2010 there were in Poland and Europe (Sweden, Germany, Italy), a number of catastrophic events that led to the widespread network failure (blackouts), and whose causes were severe weather anomalies. As a result of increasing tensions and despite an avalanche of efficient sources of power, many customers were devoid of power for several days which in turn led to significant economic losses. Moreover, the process of restoring power supply was a complicated and time consuming.

These facts confirm that the historical structure of energy systems is no longer suitable to the task of increasing economic requirements and climate change. Particular importance is the lack of information between transmission systems about the actual state of each device.

3.2.2 Lack of exploit the potential which functions in the systems of decentralized sources

Global energy demand is increasing rapidly due to economic development, growth service level and quality of life. It is estimated that the growth rate is approximately 2,2% per year. Aging energy infrastructure, both in Poland and Europe needs to modernize and maximize the efficiency of energy flow.

Those conditions require intensified activity to increase production capacity of electricity. It is therefore essential that the different sources of electricity generation had its share in meeting the needs of customers, that is to varying degrees and at different levels.

There is a huge demand for power grid to enable connection of distributed generation sources of renewable energy especially, those that are less harmful for the environment.

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[2] Sedler B. - *Smart electricity networks – as condition for the development of green energy*. Scientific and Technical Foundation, Gdańsk 2011.

Picture 1: Overview of Smart Grid investment and implementation across the EU (source: JRC, IE). Projects represented can span over more than country and can include more than one category. Three projects are not represented in this Picture: Kriegers Flak project, a Super Grid between Germany and Denmark, total investment of 507 M€; Smart Meter Roll-out and AMI in UK, estimated investment of 11897 M€; and Smart Meter Roll-out in Sweden, spanning in approx. 50 projects and amounting a total investment of approx.1500 M€.

Figure 9. Overview of Smart Grid Investments and Implementation across the EU
(*source: European Commission, "Communication from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions. Smart Grids: from innovation to deployment"*)

3.2.3 The existing power system does not allow for the proper implementation of the new ecological findings in the European Union

The advent of electric vehicles in use is a form of energy storage but also they will require an increased demand for energy. Consistent development of distributed energy storage technologies and related new products and services bring the demand for new smart energy system.

3.2.4 Intelligent Energy will introduce the benefits from the prosumption

It is important for the raise of production capacity and the country's energy security to provide for many customers the possibility to generate and sell power to the system which will allow for more efficient use of available primary and secondary sources in each region. Without the implementation of the Smart Grid the benefits from the prosumption task will not be possible.

3.2.5 Increasing efficiency of the primary and secondary energy

The current energy system does not allow for ongoing monitoring and effective management of electrical energy use and energy recovery which can be used mainly on a local scale

Moreover, thanks to the smart grid will reduce the cost of disaster recovery and the associated loss of produced energy[3].

4 Details of the implementation of the smart grid in the energy system in Europe and the world

The functioning smart grid in the advanced stage which will work effectively and meet the needs of today's digital economy requires implementation of the following elements:

- smart meters and related advanced structures - AMI,
- automatic transmission and distribution networks,
- applications including the integration of the whole energy system,
- software applications tailored to customer behawior,
- energy storage.

Each of these constituent elements is implemented to varying degrees in national and international projects of the European Union countries.

According to the data contained in the Commission Communication to the European Parliament (dated 12 April 2011), it was estimated that in EU countries was invested in the last decade, more than € 5,5 billion in about 300 projects to implement smart grid. As a comparison, the U.S. has invested $ 8,1 billion and in China $ 7,3 billion[4].

The European Union is still in early stages of implementing smart grid especially if one takes into account that for 2020. is planned to invest in this venture € 56 billion.

As it follows from the figure above, a leader in investment projects regarding smart meters, are Italy with national Telegestore project where the system is mainly based more on reduction non-technical loss than the same energy savings (see Fig. 9).

Significant values of smartmetering investment in Europe include France, Sweden and Finland.

High investment in smart meters have a large stake in the structure of the Smart Grid projects in many European countries because of the expectations for the following issues:

- reducing the cost of theft of energy,
- possibility of remote activation and deactivation of services,
- rapid detection of energy flow on the network,
- a better management of difficult customers (bad payers).

In the future these investments will be the basis of additional benefits derived from the consumer supply, in so-called the dynamics of pricing preview, which depends on the future functionality of the system, the attached application, connection of intelligent devices.

Previously installed smart meters allow consumers to reduce energy consumption to 10% (according to the project Telegestore, Italy). By contrast, many European projects, point to a much greater impact on CO_2 emissions reduction, that is from 9% to 15%.

It is also important and interesting that the implementation of smart metering in modern economies will also allow the development of intelligent devices for the consumer. It is expected that the market for this kind of goods will grow globally from $ 3,06 billion. in 2011 to $ 15,12 billion. (Tab 2) in 2015. where most of its shares will take place in the U.S. (46,6%), China (11,6%), UK (4,8%), Austria (2,8%), and the rest of the world 34,2%[5].

An important part of the process of implementing smart grid to the full extent in the European system are the following:

- safe integration of distributed energy resources (DER) (distributed generation, storage, electric cars),
- possible response of the consumer to price (DR),
- security integration of renewable sources (RES).

[3] Kowalak T. - *The implications of smart grid Technologies (smart meters) – smart meters and smart grids – for the security of electricity supply.* Monographs Technical University of Lodz, 2011.

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Table 2. The estimated global market for smart devices according to individual products in 2015. (billion $)
(*source: Zpryme Research & Consulting - Insights Smart Grid: Smart Appliances, March 2010*)

Washing Machines	$ 3,542
Refrigerators	$ 2,693
Dryers	$ 2,236
Dishwashers	$ 1,354
Freezers	$ 1,166
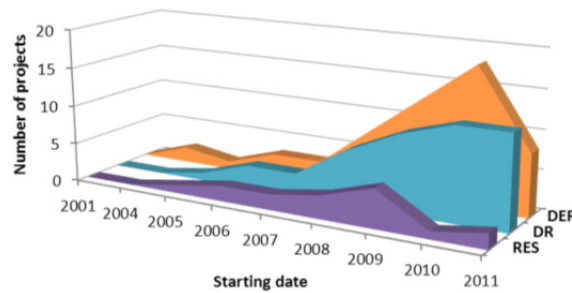
Figure 10. Trend of development projects focusing on intelligent network elements such as RES, DER, DR
in the years 2001-2011
(*source: European Commission, Institute for Energy - Smart Grid Projects In Europe: lessons learned
and current developments, 2011*)

Table 3. The structure of the various phases of projects to implement smart grid in Europe
(*source: European Commission, Institute for Energy, "Smart Grid Projects In Europe:
lessons learned and current developments, 2011*)

Projects	R&D	Demonstration projects	Deployment
DR	29%	71%	0%
DER	33%	67%	0%
RES	56%	44%	0%
Smart Meters	8%	60%	32%

Projects which are focusing on the integration of distributed energy resources, there is the DER and DR, are in a continuous upward trend (see Fig. 10) and most of them are mainly in their R&D and demonstration projects (Table 3). The development of these phases of the project are the result of an advanced implementation of smart meters.

DR projects are increasingly transformed into a phase of demonstration projects to increase the degree of involvement of consumers and gain their trust which is an essential element in the operation of smart grids. The benefits of energy savings on part of the consumers are at the level of 10-15% (eg. GAD Project).
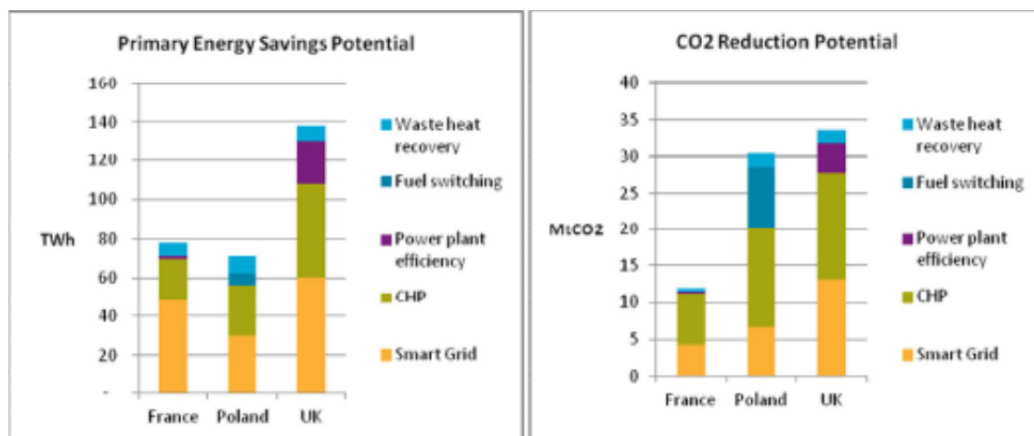
Figure 11. The structure of techniques for saving primary energy and reduce CO2 emissions
in France, Poland and Great Britain.
(*source: Brown M., McLeavey-Reville C. - Driving a resource efficiency Power Generation Sector in Europe,*
Delta Energy & Environment, May 2011)

Projects on smart meters are in a more mature phase, as evidenced by the 30% of them was located in the deployment phase, while only 8% of these projects is still in R & D (eg. OpenNode Project, OpenMeter Project, SyM2 Project).

All the projects as DSO (Distribution System Operator) which includes the Advanced Metering Infrastructure (AMI), the integration of DER and Demand Responce are based on smart meter systems and are aimed at saving energy theft in the field of logistics and operations, customer service and focused on the reduction of operating costs.

4.1   The outline of implementation projects in an intelligent polish network

The increasing Polish position in international organizations, the accession to the European Union forced Poland to participate in several obligations, which generally serve two objectives: climate protection and the full implementation of the principle of free movement of goods - one of the pillars of a United Europe.

In a view of the above-identified Polish international obligations in the field of climate protection as well as the need for more the energy markets competitiveness, the Polish energy sector is in a particular position.

The structure of the Polish electricity generation continues to dominate the emitting fuels, and there is inadequate and outdated transmission and distribution infrastructure. The economic growth imposes an increased demand for energy in the future and will lead to a deficit of power in the system and, consequently, the power cuts.

Due to the above considerations taken by Poland the smart grid initiatives, therefore, seems to be obvious. But so far, Poland is at the beginning of the implementation process, there is at 1,7% of expenditures in comparison to other European Union countries.

Because of the national energy balance analysis, implementation of smart grid is probably a necessity, but not replace, however, of investments in new generation capacity and transmission infrastructure, which so far are insufficient and also from year to year decline.

In general, energy savings can result from the possibility of using such methods and techniques such as:

- the introduction of the cogeneration process,
- increase the efficiency of power plants,
- fuel switching, recovery of waste heat and also through,
- smart grid.

Each of these methods has a significant impact on primary energy savings but also the potential for reducing CO2 emissions (see Fig. 11).

Table 4. Polish projects in the process of implementing smart grid in power networks
(*source: European Commission, Institute for Energy - Smart Grid Projects In Europe: lessons learned and current developments, 2011*)

Name of project	Organisation	Co-untry	Description of project	Period
AMI	ENERGA-OPERATOR SA (PL)	PL	The project is focused on Increasing the effectiveness of operational activity and facilitating management of the network and its development; Remote management of meter systems and obtaining meter data; Activation of clients in energy effectiveness and dispersed generation;	2010-2017
Introduction of emergency Demand Side Response (DSR) programs	PSE Operator S.A.(PL)	PL	The main goal of the pilot project is to gain practical experience of the functioning of emergency DSR programs in Smart Grid/smart Meters environment. This experience will be used to develop the target DSR programs.	2011-2012
The metering data processing and central repository concept	PSE Operator S.A.(PL)	PL	The goal of the project is to prepare cost benefit analysis of smart metering implementation in Poland and to develop the legal and organizational framework to implement metering data processing and central repository concept.	2010-2011

Figure 12 The largest planned project AMI in Poland conducted by AMI-Energa Operator.
(*source: Energa – Operator SA*)

The following graphics show the importance of Smart Grid in the process of primary energy savings and reduce carbon emissions. Although the initial phase of the Smart Grid, Poland has already initiated three major projects carried out by the largest operators of transmission (Table 4). There are AMI, introduction of emergency Demand Side Response and the Metering data processing and central repository concept.

They are designed to introduce smart meters and associated high-energy infrastructure (AMI project conducted by Energa), and create a basis for integrating the entire system in the construction of the future smart grid - projects conducted by PSE Operator (details of polish projects are included in Table 4).

The first and biggest project in Poland concerning the introduction of smart metering solutions for large-scale is run by Energa Operator SA, a distributor of energy from the Group of Energia (see Fig. 12). This project is called "Implementation of AMI (Advanced Metering Infrastructure - smart metering)."

Table 5. Summary and description of some international projects for intelligent energy networks,
in which Poland is a member
(*source: European Commission, Institute for Energy, Smart Grid Projects In Europe:
lessons learned and current developments, 2011*)

Name of project	Entity conducting the project	Countries	Description	Period
EU-DEEP	GDF Suez (FR)	FR, EL, UK, DE, BE, ES, SE, PL, LV, AT HU, IT, FI, CY, CZ, TR	The project brings together eight European energy utilities and aims at removing most of the technical and non-technical barriers that prevent a massive deployment of distributed energy resources (DER) in Europe. In partnership with manufacturers, research organizations, professionals, national agencies and a bank, they implemented a demand-pull rather than technology-push approach. This new approach provided three tentative "fast-tracks options" to speed up the large-scale implementation of DER in Europe, by defining three client portfolios in various market segments which could benefit from DER solutions, and by fostering the R&D required to adapt DER technologies to the demands of these segments.	2004 - 2009
EWIS - European wind integration study	ELIA SYSTEM OPERATOR SA (BE)	BE, AT, DE, FR, PT, ES, PL, UK, EL, IE, DK, CZ, NL	The project aims to work with all the relevant stakeholders especially representatives of wind generation developers. The study will use results from detailed network and market models of the European transmission system for scenarios representing immediate and longer-term needs. The recommendations will be aimed at developing, where possible and appropriate, common European solutions to wind integration challenges	2007- 2009
Micro-Request-Based Aggregation Forecasting and Scheduling of Energy Demand, Supply and Distribution (MIRABLE)	SAP AG (DE)	EL, DE, PT, NL, DK, CH, IT, ES, FR, PL, MK, UK	The project's main goal is to develop a concept for flex-offers that specify electricity demand and supply which is flexible in time and amount and an infrastructural approach to process lots of these flex-offers issued by small consumers and producers in near real-time. The possibility to shift demand within the mass of households developed within the MIRACLE project will allow for a higher share of fluctuating renewable energy sources in the energy mix on the grid and reduce the peak demand. We expect that the share of RES can be increased by 5% and that the peak demand can be reduced by 8-9% (but at least by 5%) for the total grid. We will furthermore reduce the mean time between transactions, which will result in more stability of the energy grid but also in reduction of costs of BRPs, by reducing the difference between their planned and actual electricity schedules.	2010 - 2013
SUSPLAN	SINTEF ENERGIGI-FORSKNING A/S (NO)	PL, RO, DE, AT, UK, NL, ES, BG, CZ, IT, RS	The overall impact from SUSPLAN is contribution to a substantially increased share of renewable energy sources (RES) in Europe at an acceptable level of cost, thereby increasing security of supply and competitiveness of RES industry. The main objective is to develop guidelines for more efficient integration of RES into future infrastructures as a support for decision makers at regional as well as Pan-European level. The guidelines shall consist of strategies, recommendations, criteria and benchmarks for political, infrastructure and network decision makers and power distributors with a time perspective 2030-2050.	2008- 2011
web2energy	HSE AG (DE)	DE, NL, AT, PL, CH	The project Web2Energy is directed to implement and approve all three pillars of "Smart Distribution". Smart Metering – the consumer participates in the energy market Smart Energy Management – Clustering of small power producers. Smart Distribution Automation – higher reliability of supply.	2010- 2012

Representatives of the operator Energa maintain that smart meters are the basis for intelligent network which is confirmed by the trend in the construction of pan-European smart grid.

In addition to the end of the first quarter of 2012, the company plans to install 100.000 smart meters in such regions like Kalisz, Drawsko Pomorskie and Hel in Poland.

Hel additionally has been selected by Energa as the location of Poland's first smart grid pilot project. In this place is also tested the possibility of the distributed generation (that is energy production in small sources, such as domestic solar panels, or agricultural biogas plants).

Energa assumes that all devices installed will become part of the infrastructure planned for the future grid.

To 2017 above energy company plans to replace the measuring devices in all of its customers, which is almost 3 million. Total project cost is estimated at over 1 billion zł.

The industry's largest companys like PSE Operator SA and also by Tauron Katowice, Vattenfall and Enea prepare pilot projects on a smaller scale than Energa. The aim of these projects is to assess the effectiveness and costs of the introduction and use of available technologies.

In addition to smart grids projects that are implemented by the major network operators in Poland, there are also international projects where Poland is actively cooperate. There are the following projects: EU-DEEP, EWIS, MIRABLE, SUSPLAN, Web2energy. These projects are mainly aimed at accelerating the introduction of a wide range of DER investment in Europe, identification of customer requirements and their segmentation (EU-DEEP, MIRABLE), the introduction of intelligent energy distribution (Web2energy), the increase share of renewable energy sources (Mirable, Susplan) and especially wind power (EWIS) - detailed description of international projects with the participation of Poland – Table 5)

4.2 Social background of inteligent network introduction

Despite many projects that are implemented throughout the world, in European countries, and also in Poland there is important a public knowledge in the topic of smart grids as a condition for the success of all plans in the sphere of increasing the efficient use of existing potential energy and climate protection.

The results presented in the "2011 IBM Global Utility Consumer Survey" showed, that many consumers in the world do not understand what makes up the price of energy and do not see the benefits of the new technologies.

IBM social study, which aimed to investigate the needs of energy consumers around the world, covered 10 thousand. people in 15 countries around the world, including Poland. It showed what kind of knowledge the energy consumers need to reduce power consumption and benefit from the intelligent energy. More than 60 percent people do not know the meaning of terms such as smart grids and smart meters.

Similarly, in Poland, where smart grids is almost unknown. As many as 76 percent. Polish respondents did not know what are the intelligent networks, and knowledge of the term "smart meter" is significantly below the global average. Polish people declare that they know very well for what they are paying. - 61 percent of respondents, while 54 percent Polish respondents do not realize that their energy supplier offers green energy or not.

The study also showed a close relationship between users knowledge, the expectation of change and acceptance of new energy initiatives. 61 percent. respondents possessing an established knowledge of energy and its prices have positive view of plans to create smart grids and smart meters. Among people with little knowledge on this subject, only 43 percent people welcome these plans.

We noted significant progress in the field of new energy saving technology. Meanwhile, many consumers do not understand the offers sent to them and the benefits that come from them. This study indicates the need for education with clear terms and using appropriate communication channels. People want to save, you need just to show them how to do it. The perception, expectation and performance of energy consumers have changed over the last 4 years. Despite the efforts of power engineers and the entire industry to create a friendly power saving utility customers, many of them still have no information or motivation to make better choices of energy.

5   Summary

This paper is the result of statistical, economic analyzes and studies of literature in the field of innovative technologies in the supply of electricity and the efficiency of its utilization in the economy.

Smart energy networks are an innovation that among the various technologies holds an important place in the process of saving energy and reducing CO_2 emissions. Moreover, the idea of the system architecture and operation of such grids allows for supporting of energy security and it is more suited to the action and the needs of modern digital economy.

Consequently, a number of projects in Europe but also in Poland put smart grids into economic reality.

So far, Europe's capital expenditures were focused on the implementation of smart meters with advanced structure of the AMI which, according to the results of the project in Italy Telegestore makes energy savings of 10% and also has an impact on reducing carbon emissions by 9% to 15%. Additionally important is the fact that Smart Metering will also affect the development of intelligent devices that will not only support saving energy but also contribute to economic growth.

In the process of implementation of smart grids in the full range there are also important investment in technologies for the integration of distributed energy resources, the integration of renewable energy sources and technologies Demande Responce enabling the customer to actively participate in energy systems.

All of these technologies that will lead to the creation of smart grids in Europe will promote energy security and increase the energy efficiency and the impact on economic growth. However, despite the above considerations there should also be noted that the success of the project is also dependent on the awareness and the knowledge of each participant's energy system, which will allow to increase the economic benefits and social objectives with particular reference to the climate and the environment.

6   References

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ASSESSING THE IMPACT OF ERP IMPLEMENTATION IN THE SMALL ENTERPRISES

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Abstract: For a SME (small and medium-size enterprise) to operate competitively in an international and local market, it is necessary for it to deal with its tasks in an efficient and practical way; this can be achieved by the systematic analysis of the undertaken tasks in relation to the company's organizational and economical ability for their completion. The author suggests in this paper that the assessment of such an implementation depends on a firm's intention to use the ERP system to achieve strategic goals. The author discusses the issue of the Balance Scorecard method being used to assess the impact of an ERP system implementation on the performance of a small service enterprise. Using a research results, the author illustrates the possibility to assess the implementation of an ERP system in the small enterprises.

Keywords: ERP systems, Balance Scorecard, assessment of the implementation of an ERP system.

1   Introduction

The fact that ERP (Enterprise Resource Planning) systems are in demand as a support tool in management is proven by their dynamic development and a significant growth in their sales (Al-Mashari et al. [1]). Since all companies, including small and medium-size enterprises, can buy the same software, it can be clearly argued that the software itself is not the sole source of competitive advantage (Davenport [7]). It follows from the theory of competitive strategy that, if an organization chooses to implement an ERP, the organization will seek ways to derive strategic value from the ERP (Mata et al. [18]). Many organizations follow a change of management plan in which the strategy is changed before any complementary changes in people, processes, and technologies are implemented (Austin et al. [3], Lassila and Brancheau [14]). An ERP system opens new opportunities for strengthening a distinctive strategic position (Poston and Grabski [20]). For an SME (small and medium-size enterprise) to operate competitively in an international and local market, it is necessary for it to deal with its tasks in an efficient and practical way; this can be achieved by the systematic analysis of the undertaken tasks in relation to the company's organizational and economical ability for their completion.

The post-implementation phase of an ERP system is an understudied research topic (Gattiker and Goodhue [9], Staehr et al. [25]). Several authors (Markus and Tanis [17]) indicated that the Balanced Scorecard (BSC) (Kaplan and Norton [11]) might be the most appropriate technique for evaluating the benefits of an ERP systems. Rosemann and Wiese frame the application of the BSC method to ERP systems as a form of strategic management of an ERP system (Rosemann and Wiese [24], Rosemann [23]). The author discusses the issue of the BSC method being used to assess the impact of an ERP system implementation on the performance of a small service enterprise. My notion of the success of ERP systems is motivated by using the Balanced Scorecard method. I suggest that the assessment of the implementation of an ERP system depends on a firm's intention to use the ERP system to achieve strategic goals. This article addresses the following research questions: Does the use of BSC allow to measure the achievement of strategic business objectives assumed by the implementation of an ERP system?

Enterprises functioning in the market economy have to implement changes in the systems of organization and management that they use (Patalas-Maliszewska and Krebs [21]). This paper examines the long-term effects of ERP system revisions using the Balanced Scorecard method (BSC) for SMEs, the information is based on the research results (survey in six selected companies). The next section presents a review of the appropriate research. It next shows that an ERP system impacts the strategic goals of a firm and that four Balanced Scorecard dimensions are applicable to assess the benefits and measure the value-added contributions of ERP systems. The paper closes with a table of the correlation between defined indicators and measures of strategic impact to achieved from the implementation of an ERP system.

2   The Balanced Scorecard as a method for assessing the implementation of an ERP system

Measuring the business value of IT investments has been a major challenge for researchers and professionals (Dehning and Richardson [8], Kohli and Grover [13]). Aral and Weill [2] classify IT investments into four different types, according to their strategic purposes: (1) infrastructure investments, (2) transactional investments, (3) informational investments, (4) strategic investments. The author suggests that the small companies need to be assess by the implementation of the ERP system in the strategic perspective. I argue, that the benefits on the strategic level of investment in IT may take some time to materialize (Brynjolfsson and Hitt [4]). In particular, prior studies use different time lags that range from one to seven years and find inconsistent results (Brynjolfsson and Hitt [2], Lee and Kim [15]).

Kaplan and Norton introduced the method of the Balanced Scorecard which is a way of designing a performance measurement system that takes into account non-financial indicators. The Scorecard contains a variety of performance measurements, including financial performance, customer relations, internal business processes and learning and growth.

In this article, I try to find the best positive correlation between ERP system evaluation criteria and strategic performance of a small enterprise. In their publications, Kaplan and Norton attempted to get rid of the most commonly used system of management reporting on the basis of financial data (Kaplan and Norton [11]). They argued for achieving a balance between financial and non-financial data in management reporting. The four perspectives described above do not, however, restrict the Balanced Scorecard. According to Kaplan and Norton, the measurement system evolved into a strategic management system after a couple of years. They recognise that the basis for the Balanced Scorecard and the processes that occur in a company must be adjusted to each other periodically.

However, in my opinion, the role of the Balanced Scorecard in strategy formulation activity is wider. I maintain that the Balanced Scorecard may provide adequate feedback on the content of the implementation of an ERP system, and thus it can be used for strategic control in a company.

The strategic decision, as far as ERP system implementation is concerned, is based on the assessment of its potential advantages, resulting from the operation of such a system in the company. SMEs that are about to make a decision concerning the introduction of an ERP system tend to make an evaluation of the efficiency of the implementation (for example taking into consideration the level of fulfilment of the user's objectives) (Kłos et al. [12]). However, the process of the efficiency evaluation is very expensive, time-consuming and typically followed by complicated analyzes. Bearing this in mind, there is a demand for developing a discussion for assessing the implementation of an ERP system using the Balanced Scorecard technique.

Additional value for SMEs can be defined by an effective implementation of an ERP system. SMEs with integrated IT systems also gain a further advantage in relation to the company because it enables them to have an insight into every aspect of its operation with a precise and correct evaluation of the company's financial situation. As a performance management and measurement tool, the BSC has been used to articulate and communicate the strategy of the business, and to help align organizational, cross-department, and individual initiatives to achieve common goals (Kaplan and Norton [10]). Milis and Mercken [19] suggest, that traditional capital investment assessment mechanisms, such as payback period, ARR (Accounting Rate of Return), ROI (Return on Investment), IRR (Internal Rate of Return), NPV (Net Present Value) were difficult to use to explain the associated intangible costs and benefits before and after the ERP system implementation. Clemons and Weber [6] pointed out that most of these mechanisms were at the stage of conceptualization and could not yet be accepted by the public. Therefore, Milis and Mercken [19] finally and enthusiastically recommended the use of the Balanced Scorecard as the proper assessment mechanism to evaluate the investment project of ERP system implementation.

Based on a review of the Balance Scorecard used in prior studies, I chose twenty eight ERP system evaluation criteria as the most important for my study (see Table 1). The introduction of ERP system should improve the level of the defined indicators in each perspective of BSC in the company.

Table 1. The strategic objectives to achieved from the implementation of an ERP system
and of the indicators, which help to measure it's in the company
(*source: own study*)

The strategic objectives to achieved from the implementation of an ERP system (modules: Contracts, Sales, Accounting, Mobile sales) in each perspective of BSC in the company	Indicators, which help to measure the defined objectives
the Customer Perspective the objective: increasing the efficiency of customers relationship management	1) Customer relationship management cost/income of sale 2) Sale's cost/income of sale 3) Number of customers 4) Premium Brand 5) Market share 6) Customer satisfaction (survey) 7) Customer loyalty (the re-purchase by customers) 8) Number of new products in the sale 9) Number of new products in relation to competition
the Learning and Growth Perspective the objective: increasing the productivity of the company	10) Productivity ratio of assets 11) Ratio of products, goods and materials 12) Participations rate of inventories in current assets 13) Participation rate of short-term receivables in current assets 14) Participation rate of short-term investment in current assets 15) Productivity ratio of total assets 16) Productivity ratio of fixed assets
the Financial Perspective the objective: increasing the profitability of the company and improving the reliability of financial reporting	17) Ratio on Sale 18) Return on Assets 19) Return on Equity
the Business Process Perspective the objective: increasing the effectiveness of human resource management (HRM)	20) Added value of human capital 21) Return of investment of human capital 22) Economic added value of human capital 23) Labor productivity 24) Equal opportunity 25) Work experiences 26) Employee's cost/ income 27) Salary's cost/income 28) HRM cost/income of sale

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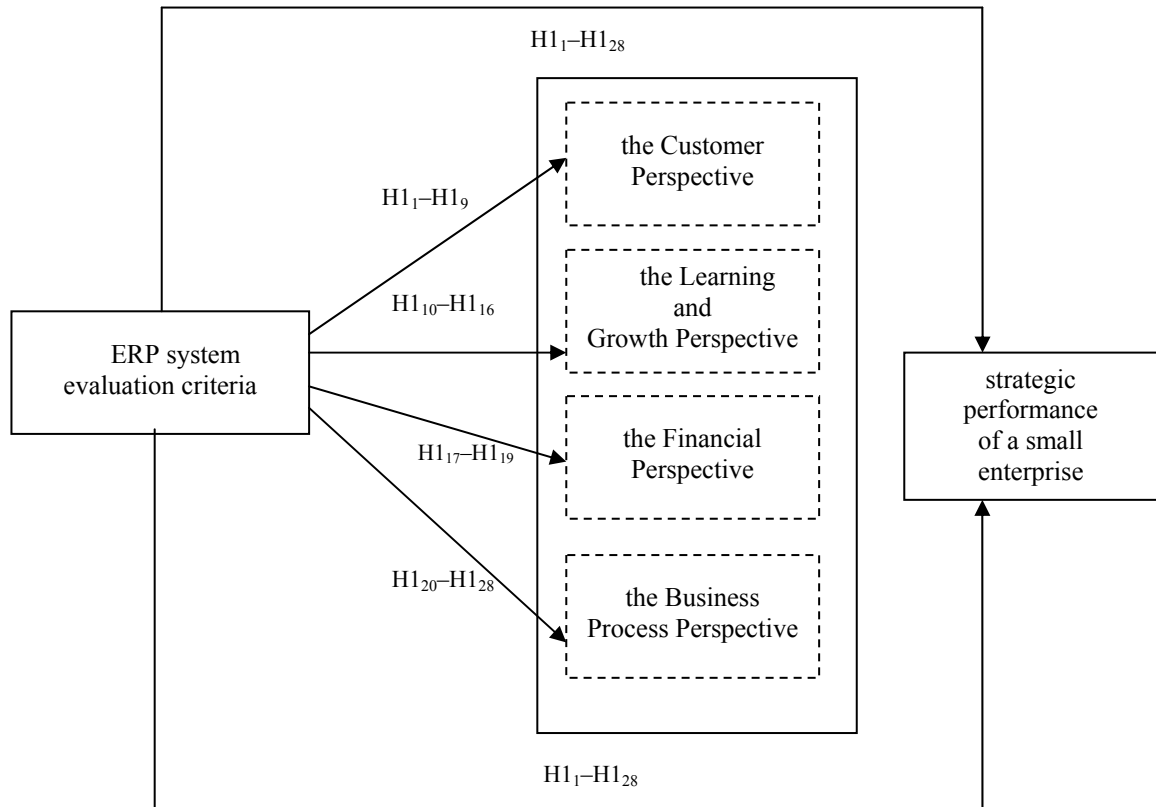
Figure 1. Research model and the hypotheses
(*source: own study*)

The research hypotheses: $H1_1$–$H1_{28}$ are formulated: ERP system evaluation criteria (1–28) is positively correlated with strategic performance of a small enterprise.

My research model is presented in Fig. 1.

3   Methodology

In order to analyze the possibility of assessing the strategic impact of the post-implementation phase of an ERP using the BSC method, the survey examined the ERP implementation experiences of 6 small companies in Poland. Information on the indicators were obtained through direct interviews conducted in these companies. In order to present the possibility of hypotheses verification let me consider the small companies, that deal with providing services in the form of projects for both organizations and individual customers. The main areas of the companies correspond to the following functions: the sale, the supply, the order scheduling, the service, the accounting, human resources management, export/import transactions. Those companies completed, in 2008, a project to im-

plement an ERP system and the following modules were implemented: Contracts, Sales, Accounting, Admin, Mobile sales. The following strategic objectives were established to achieved from the implementation of an ERP system:

- increasing the efficiency of customers relationship management,
- increasing the productivity of the company,
- increasing the profitability of the company,
- improving the reliability of financial reporting,
- increasing the effectiveness of human resource management.

In Table 2 the values of defined indicators from six companies in 2011 are given.

Table 2. Research results from six selected small enterprises, that completed, in 2008,
a project to implement an ERP system
(*source: own study*)

BSC	Indicators/Company	E1	E2	E3	E4	E5	E6
the Customer Perspective	(1) Customer relationship management cost/income of sale	0,01	0,04	0,02	0,01	0,01	0,02
	(2) Sale's cost/income of sale	0,02	0,04	0,03	0,01	0,01	0,02
	(3) Number of customers	24	48	35	28	14	22
	(4) Premium Brand	-	-	-	-	-	-
	(5) Market share	-	-	-	-	-	-
	(6) Customer satisfaction (survey)	-	-	-	-	-	-
	(7) Customer loyalty (the re-purchase by customers)	-	-	-	-	-	-
	(8) Number of new products in the sale	5	4	12	10	1	3
	(9) Number of new products in relation to competition	-	-	-	-	-	-
the Learning and Growth Perspective	(10) Productivity ratio of assets	1,5	1,7	1,2	1,3	0,9	1,5
	(11) Ratio of products, goods and materials	0,95	0,92	0,99	0,89	0,8	0,99
	(12) Participations rate of inventories in current assets	0,26	0,33	0,15	0,32	0,14	0,28
	(13) Participation rate of short-term receivables in current assets	0,6	0,4	0,7	0,3	0,4	0,6
	(14) Participation rate of short-term investment in current assets	0,11	0,32	0,22	0,12	0,09	0,31
	(15) Productivity ratio of total assets	1,57	1,8	1,2	1,7	1,9	1,4
	(16) Productivity ratio of fixed assets	4,84	8,9	5,4	6,78	5,2	4,7
the Financial Perspective	(17) Ratio on Sale	0,02	0,05	0,01	0,03	0,01	0,01
	(18) Return on Assets	0,06	0,09	0,06	0,04	0,03	0,04
	(19) Return on Equity	0,12	0,09	0,11	0,08	0,15	0,02
the Business Process Perspective	(20) Added value of human capital	109	89	120	110	109	112
	(21) Return of investment of human capital	0,13	0,09	0,07	0,06	0,13	0,15
	(22) Economic added value of human capital	-44	10	-23	-24	-54	8
	(23) Labor productivity	880	920	640	780	520	900
	(24) Equal opportunity	-	-	-	-	-	-
	(25) Work experiences	-	-	-	-	-	-
	(26) Employee's cost/ income	0,07	0,05	0,06	0,04	0,03	0,07
	(27) Salary's cost/income	0,08	0,06	0,07	0,05	0,04	0,08
	(28) HRM cost/income of sale	0,02	0,03	0,04	0,02	0,01	0,02
Output	Performance	**679**	**452**	**339**	**544**	**242**	**852**

Table 3. Research results from multivariate correlation analysis
for the Customer Perspective in the BSC
(*source: own study*)

	correlation	tolerance	t(3)	p
(2) Sale's cost/income of sale	0,902869	0,997828	3,626763	0,036075
(3) Number of customers	0,854221	0,997828	2,796654	0,068042
(8) Number of new products in the sale	-0,092813	0,989440	-0,160157	0,882934

Table 4. Research results from multivariate correlation analysis
for the Learning and Growth Perspective in the BSC
(*source: own study*)

	correlation	tolerance	t(3)	p
(11) Ratio of products, goods and materials	0,343906	0,645361	0,634355	0,570917
(12) Participations rate of inventories in current assets	0,699687	0,630083	1,696264	0,188405
(13) Participation rate of short-term receivables in current assets	-0,087515	0,939400	-0,152164	0,888715
(14) Participation rate of short-term investment in current assets	0,610619	0,886116	1,335509	0,273995
(15) Productivity ratio of total assets	0,113475	0,897827	0,197822	0,855830
(16) Productivity ratio of fixed assets	0,845865	0,934227	2,746694	0,070939

Finally, based on the indicators values (Table 2), the research constructed values of correlation between an ERP system evaluation criteria (1–28) with strategic performance of a small enterprise and with net benefits of a small enterprise for each of four perspective.

4   Data analysis and model testing

In order to verify the research hypotheses it is used multivariate correlation analysis for each of the defined perspectives in the BSC. In the Table 3-6 the research results are given:

- For the Customer Perspective (Table 3)

In the Customer Perspective in the BSC: (2) Sale's cost/income of sale and (8) Number of customers (the defined ERP system evaluation criteria) are the most positively correlated with strategic performance of a small enterprise ($H1_1$–$H1_9$).

- For the Learning and Growth Perspective (Table 4)

In the Learning and Growth Perspective in the BSC: (12) Participations rate of inventories in current assets and (16) Productivity ratio of fixed assets (the defined ERP system evaluation criteria) are the most positively correlated with strategic performance of a small enterprise ($H1_{10}$–$H1_{16}$).

Table 5. Research results from multivariate correlation analysis
for the Customer Perspective in the BSC
(*source: own study*)

	correlation	tolerance	t(3)	p
(17) Ratio on Sale	-0,123849	0,459198	-0,19487	0,863498
(18) Return on Assets	0,053447	0,461503	0,08430	0,940493
(19) Return on Equity	-0,796534	0,989239	-1,83950	0,207213

Table 6. Research results from multivariate correlation analysis
for the Business Process Perspective in the BSC
(*source: own study*)

	correlation	tolerance	t(3)	p
(20) Added value of human capital	0,032976	0,998731	0,065989	0,950553
(21) Return of investment of human capital	-0,013361	0,803417	-0,02314	0,982989
(22) Economic added value of human capital	-0,483507	0,793708	-0,95672	0,409286
(23) Labor productivity	-0,837361	0,370455	-2,65317	0,076786
(26) Employee's cost/ income	0,273820	0,465282	0,49312	0,655768
(27) Salary's cost/income	0,273820	0,465282	0,49312	0,655768
(28) HRM cost/income of sale	0,074042	0,983620	0,12860	0,905813

- For the Financial Perspective (Table 5)

In the Financial Perspective in the BSC it cannot be defined ERP system evaluation criteria, that are positively correlated with strategic performance of a small enterprise ($H1_{17}$–$H1_{19}$).

- For the Business Process Perspective (Table 6)

In the Business Process Perspective in the BSC (26) Employee's cost/ income and (27) Salary's cost/income (the defined ERP system evaluation criteria) are the most positively correlated with strategic performance of a small enterprise ($H1_{20}$–$H1_{28}$).

It is found the most significant relationship between the output of the research hypothesis and the defined ERP system evaluation criteria in the each of four BSC perspectives. Thus enables me to built the space to measure the strategic effects of the implementation of ERP systems for small businesses (see Fig. 2).
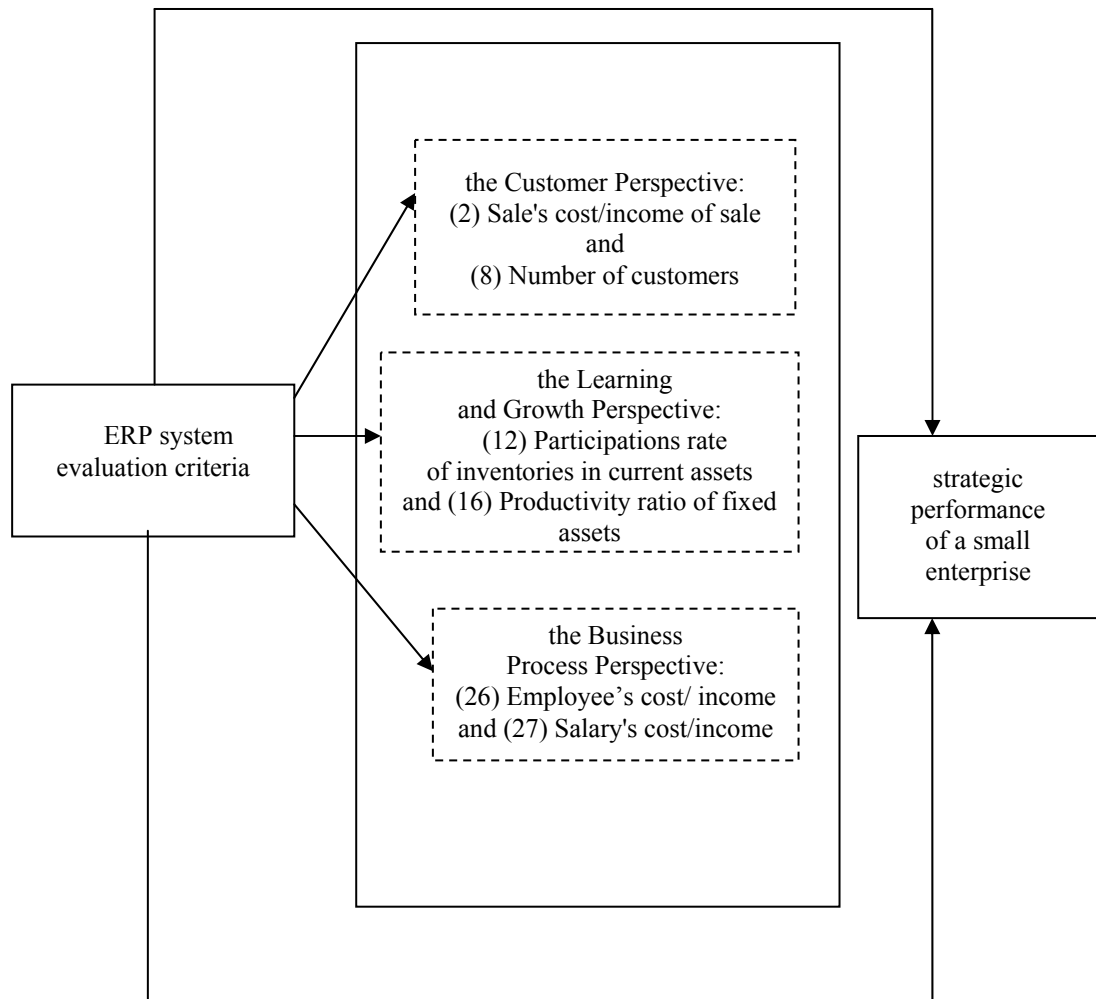
Figure 2. The space to measure the strategic effects of the implementation
of ERP systems for small businesses
(*source: own study*)

Further work is carried out to build a broader database to find a better space to assessment of the implementation of the ERP system.

For a more detailed analysis of the applicability of the proposed approach a case study is presented. The main areas of the company (E1) correspond to the following functions: the sale, the supply, the order scheduling, the service, the accounting, human resources management, export/import transactions. This company completed, in 2008, a project to implement an ERP system and the following modules were implemented: Contracts, Sales, Accounting, Admin, Mobile sales. The author assesses the implementation of an ERP system in accordance with the defined space to measure the strategic effects of the implementation of ERP systems for small businesses (see Fig. 2).

The Customer Perspective: the strategic objective to achieve: increasing the efficiency of customers relationship management, the indicator: the number of customers since the implementation of an ERP system (since 2008).

So, the number of customers since the implementation of an ERP system (since 2008) and a forecast of the number of customers for the years 2012-2014 is given (see Fig. 3).

The strategic goal of an ERP system is the transformational capability of the organization to meet the new needs of its customers and the needs of any new customers. This also includes strategic partnering with customers – carried out between a network of about 300 stores.
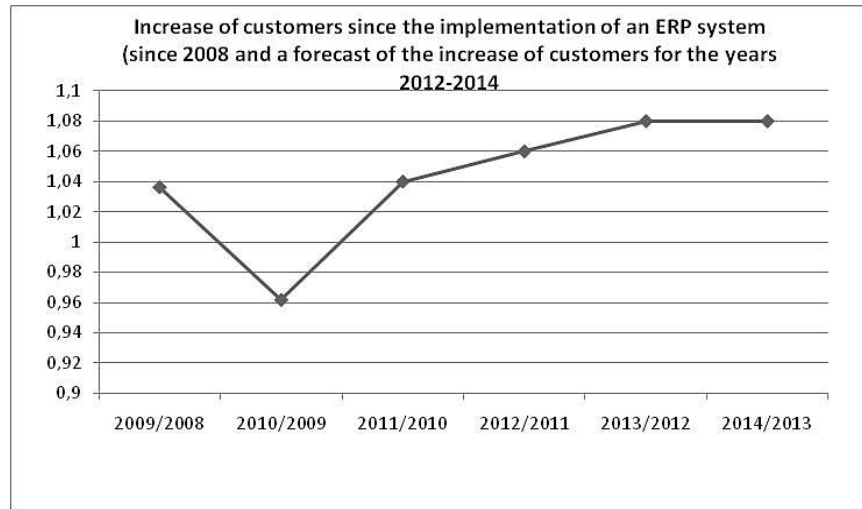
Figure 3. Increase of customers since the implementation of an ERP system (since 2008) and a forecast of the increase of customers for the years 2012-2014
(*source: own study*)

Figure 4. The values of productivity indicators since the implementation of an ERP system (since 2008) and the forecast values of productivity indicators for the years 2012-2014
(*source: own study*)

Also the following issues have been defined in this network:

- a lack of communication between the network partners and suppliers,
- an inability to transmit orders to suppliers for the purchase in a uniform manner,
- an inability to download electronic invoices in a uniform manner,
- an inability to send data on promotions, newsletters and current prices,
- a lack of opportunities to exchange information among its members such as through the ability to create surveys, newsletters,
- a lack of reporting on the performance of the network.

Extending the functionality of the ERP system for Business to Business solutions can help the organization to solve these problems and correct potential future problems with customers.
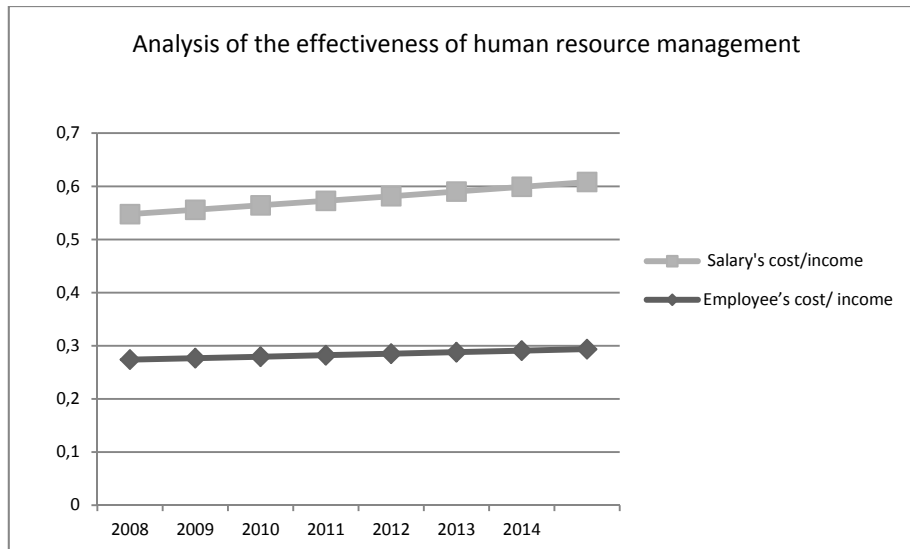
Figure 5. The values of the effectiveness of human resource management since the implementation of an ERP system (since 2008) and the forecast values for them for the years 2012-2014
(*source: own study*)

The Innovation and Learning Perspective: the strategic objective to achieve: increasing the productivity of the company, the indicators: participations rate of inventories in current assets and productivity ratio of fixed assets (since 2008).

So, the values of defined indicators since the implementation of an ERP system (since 2008) and the forecast value for the years 2012-2014 are formulated (see Fig. 4).

The implemented ERP system can be extended with additional functionality that will enable the creation a Business to Business system. The task of the new system will be to automate logistics processes within the company's network.

The implemented ERP system can be extended with additional functionality that will enable to create a Business to Business system. The task of the new system will automate logistics processes within the company's network:

- automatically send orders to suppliers for a purchase of a unified manner,
- the automatic retrieval of electronic invoices in a uniform way,
- the automatic routing of data on promotions, newsletters, current prices,
- the automatic exchange of information among its members, for example, through the ability to create surveys, newsletters,
- reporting on the performance of the network.

The Business Process Perspective: the strategic objective to achieve: increasing the effectiveness of human resource management, the indicators: employee's cost/income and salary's cost/income, which help to measure the defined objective: added value of human capital.

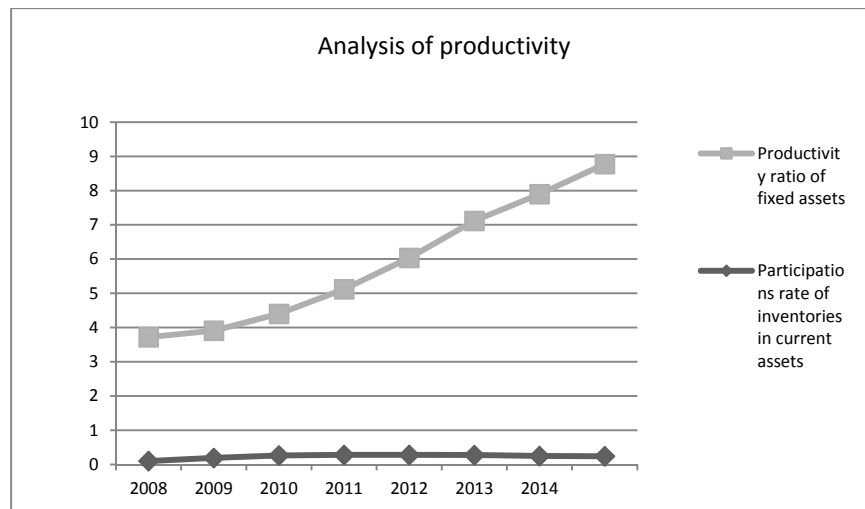So, the value of the defined indicators since the implementation of an ERP system (since 2008) and the forecast value for the years 2012-2014 (see Fig. 5).

In accordance with the strategic goals: extending the functionality of the ERP system for Business to Business solutions allows for the following business processes to be defined:

- the sales process - improving the exchange of commercial information within the network - between members and the network operator,
- comprehensive data exchange: the exchange of purchase orders, sales invoices exchange, registration of invoices,
- the promotional process - generating and distributing data on promotions, newsletters, current prices within the network,
- customer relationship management - improving the exchange of commercial information within the network - between members and the network operator,
- comprehensive data exchange: exchange regarding customer satisfaction surveys, newsletters,

- the process of information management and reporting - data exchange on how to optimize business processes and partners, all through the mechanisms of effective management information provided by multilevel analysis.

In the real case study, the ERP system has impacted enhanced revenue opportunities and improved market positioning. SMEs, unlike large companies, do not have the capital to purchase such tools, as well as full implementation of an ERP system. The post-implementation phase of an ERP should improve the level of the defined indicators in each perspective of the BSC in the company. The analysis shows that in a given company there is a need to develop ERP system functionality.

It was demonstrated through a real case study that the Balanced Scorecard may be an appropriate approach for defining the success of ERP system and establishing the trends of a firm's development in accordance with the strategic goal. It is hoped that this case study will help to identify some of the capacity of the system ERP.

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SUSTAINABLE MARKETING -
A NEW ERA IN THE RESPONSIBLE MARKETING DEVELOPMENT

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Abstract: The purpose of this paper is to draw to the attention of those involved in marketing - scientists, educators, researchers, marketers, and professionals dealing with the implementation of marketing processes - the responsibility which rests upon them in the face of rapid social change worldwide through increasing global economic turbulence, a continuously widening gap between rich and poor societies as well as the galloping degradation of the natural environment. The paper is a critical analysis and literature review of marketing covering recent studies on marketing issues in relation to the concept of sustainability. Faced with increasing criticisms of a one-dimensional profit driven approach, the marketing concept requires re-branding to address issues of sustainability. Intense strategic discussion is required concerning the need to change attitudes that promote and implement modern marketing, starting from changes in the consumption model through the creation of commercial proposals, which will positively shape the future of both market exchange and social life. Moreover, it is postulated that marketers present to consumers an attitude of active and responsible management, as well as openness and honesty in market communication. The article introduces discussion on sustainable marketing and its fundamental importance in the development of marketing theory in Poland; taking into account current debates voiced in Poland - often based on imprecise interpretation of the marketing process. There exists therefore, a need for a thorough analysis and standardisation of understanding marketing theory and consequently the introduction of new concepts and new practices into the marketing process.

Keywords: sustainable marketing, responsible consumption, social responsibility.

1 Introduction

Economic development takes place with the active participation of marketing. Without exception, we are all participants in a changing market - every member of society will sooner or later become a consumer. Marketing undoubtedly acts as a stimulus to the development and improvement of living standards [12].

The individual concepts of marketing and sustainability are not new; in fact, both have evolved over several decades into drivers of strategy, competitiveness and innovation. It is only recently however, that the term 'sustainable marketing' was introduced into the business world and commenced a rapid re-branding of marketing as an industry. Since the beginning of the twentieth century and most intensively during the last sixty years marketing has evolved (see Fig. 1) - commencing as a product driven approach focused on intensively growing sales (Marketing 1.0) to a consumer centric focus (Marketing 2.0). Today we are witnessing the emergence of a new era, defined as Marketing 3.0, a value-driven era, where people no longer perceived as a target consumer market base on demographic factor but rather thoughtful and intelligent partners with emotions, feelings and specific spiritual values [72].

The current socio-economic landscape is shaped by two powerful forces: technology and globalization. Consumers expect organisations, operating both in market and society, to provide solutions that will make the globalised world a better place to live.

Despite contributing to economic growth through meeting the needs of growing number of new consumer groups, marketing has also attracted considerable criticism.

„Some authors are concerned that marketers might become the *sightless psychopaths* of market forces, gripped in the thrall of market capitalism with no overall vision of what they are trying to achieve" [12, p. 51].
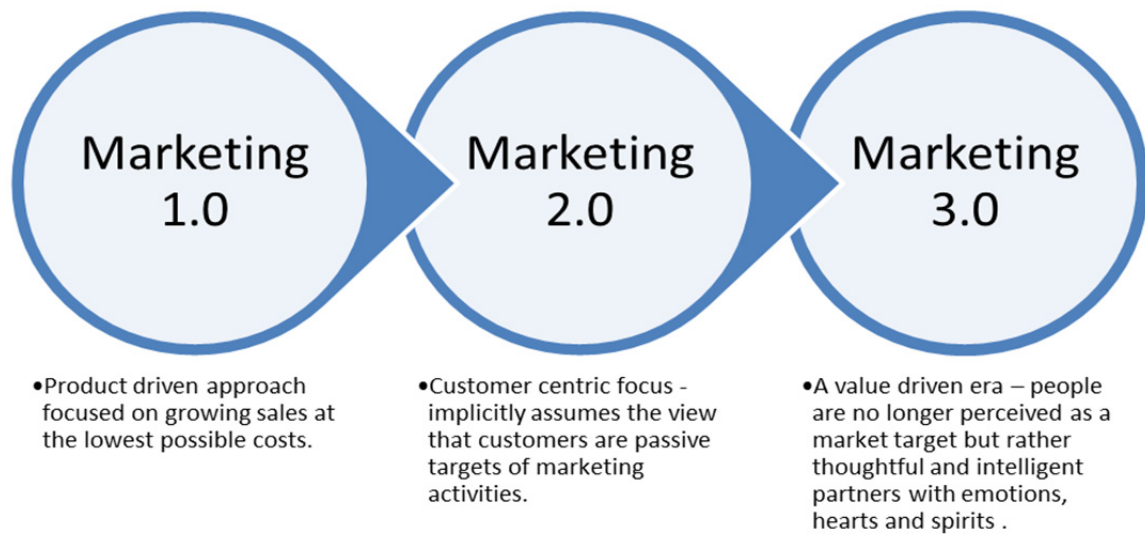
Figure 1. Marketing development
(*source: developed on the base of Kotler's concept of Marketing 3,0 [72]*)

Mounting concerns over the social and ethical account-ability of corporations, particularly following financial scandals such as Enron and Worldcom, have seen increased commitments by corporations to areas surpassing direct fiduciary duties towards their shareholders. A fundamental aspect in this process has been the rise of social responsibility from its modest resurgence in the 1950's, into a complex and well publicised notion which has increasingly become central to present day corporate decision making [22]. Individual customers have themselves raised numerous reservations about the functioning of marketing. Marketing representatives have been accused of harming consumers primarily through the imposition of high prices on products and services resulting from the high costs of distribution, advertising, promotion, and excessive margins. Marketing is also accused of using devious means that fuel the consumer's belief that the resulting value is greater than actual, as exemplified in the controversial marketing of child products Marketing to children focuses on "pester power", where child products are not targeted at the adult but rather aim to exploit a child's ability to nag their parents into buying products they would normally not purchase[1].

Consumers' great discontent and frequent frustrations are also caused by aggressive sales. Sellers are accused of carrying out commercial activities in an obtrusive way, persuading customers to purchase products or services they did not intend to purchase. The most troublesome problem for the individual consumer is the implementation of the so-called planned obsolescence strategy [71, pp. 608-613].

We should also note that the criticism of marketing is formulated not only in relation to activities aimed at individual consumers. Marketing is accused of harming society as a whole. In the format that it is presented in developed countries, marketing is blamed for creating false needs, fuelling greed, and even inciting communities to over-consumption and materialism. The World Health Organization for many years has been paying attention to the problem of obesity in developed countries [59]. Marketing also tends to promote excessive interest in having - people are judged by what they have rather than by who they are. Finally, marketing is also responsible for environmental degradation as well as trivialization and destruction of cultural and social environment [71, op. cit. pp. 613-618].

2   Social responsibility

Modern marketing and management places an important significance on building relations with the customer based on values connected with the public interest, interpersonal relationships and trust.

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[1] http://www.mediaawarness.ca/english/parents/markeing/
marketers_target_kids.cfm)

Contemporary marketing literature ([23], [53], [58], [60], [72] and [108]) discusses moral and socially responsible behavior as an integral part of the marketing process.

Despite observing an increase in understanding of the importance of social responsibility in business approach, its place in the corporate model is debatable as stated by one of the leading economists of the twentieth century "the social responsibility of business is to increase its profits" [44]. Traditional economic reasoning suggests that the wealth maximisation of shareholders, as the owners of firms, should only be considered by managers. In fact, Friedman goes as far as to consider actions diverting from such priorities as the levy of 'illegal tax'. Friedman argues that only human beings have a moral responsibility for their actions and that corporations are not human beings but solely legal entities. He further argues that social issues and problems should be the responsibility of the state and not that of corporate managers.

Milton Friedman's vigorous opposition towards the concept of social accountability of corporations has over the years become a cornerstone questioning the relevance of social responsibility in the business world. Mintzberg [84] terms social responsibility 'the most naive of concepts' though one, without which, modern day society cannot sustain itself.

Corporate Social Responsibility (CSR) is deemed 'a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis' [38]. Another definition of CSR emphasises "actions that appear to further some social good, beyond the interest of the firm and what is required by law" [82]. Heightened interest and activity in CSR has not subdued the inherent conflict between augmenting profits or adhering to the triple bottom line and, inter alia, multiple stakeholders. Crane and Matten [24] state that the apparent practice of CSR by firms is often based on self-interest and research by Moon [85] confirms that the increasing institutionalisation of CSR is related to government intervention rather than voluntary support for the concept and its long-term business case.

Despite this, studies conclude that employees and consumers respond positively towards undertaken CSR efforts implemented by firms ([15], [64] cited [63]). Furthermore, research reveals that shareholder interest in environmental and social issues has been significant-

ly increasing [4] and that, shareholder wealth, may in fact be connected to the maximizing of stakeholder surpluses. As such it is not surprising to observe a rise in ethical investments of more than 324% from US$ 639 billion in 1995 to US$ 2.7 trillion in 2007 in the United States alone [105]. The emergence of numerous ethical and sustainable indices, such as the FSTE4Good Indices, Domini 400 Social Indices, ASPI Eurozone® (Advanced Sustainable Performance Indices) and the Dow Jones Sustainability Indices portray further evidence of the expanding appetite for ethically sound investments.

Peter Ducker in the 1960s and 70s insisted that the companies and organizations applying marketing, profit or non-profit oriented, should become public bodies. None of them exist solely for themselves; they serve a social purpose and satisfy certain social needs, both of wider communities and or individuals. Performance of certain tasks, production of economic goods and providing services involve influencing individuals and their natural environment. These behaviors must have an impact on the social environment, because it is not only a source of jobs and income, also in the form of local taxes, but in many cases it becomes a source of waste and pollution. Moreover, in our pluralistic society with its various organizations, a company should feel responsible for the quantitative effects which influence lives - economic goods and services; for the quality of life in its physical, human and social aspects; and for the environment of a person in contemporary society [33, p. 35].

Some studies suggest that some forms of social responsible behavior may in fact improve future cash flows. Product differentiation may occur as a consequence of CSR, for example through the introduction of new environmentally friendly or Fair Trade lines [82]. Several studies concur that ethical practices can aid avoidance of hefty governmental fines ([14], [101] and [42]). Consequently Godfrey [50] finds that socially responsible practices can reduce risk exposure of an organisation.

Despite a lack of consensus as to the definition and implementation of socially responsible behaviors by a firm Burke & Logsdon [17] argue that CSR does create value for a firm. Their study focuses on analyzing CSR-programs as creators of strategic benefits of a company. The authors conclude that value can only be generated when CSR is imbedded in the strategic direction of the organisation.

Figure 2. Pyramid of socially responsible practice
(*source: self-study*)

It is only then that no trade-off between social and economic interests but rather CSR activities may serve both financial and social interests.

The notion that organisation use social measures such as; ISO ratings, Fair Trade and Sustainability certifications to advance their own political and economic agendas is explored by David & Rindova [28].

The authors consider such measures as 'drawing on valuation tools of quantification and simplification to compare firms along a common, often non-financial, metric' [28]. The study finds that social measures of firms are strongly related to perception rather what they are or are not. Furthermore, the aforementioned measures are considered to be 'representations and distortions of reality that enable certain actions, while constraining others'.

As depicted, the field of social responsibility evokes debate and its complexity is unquestionable, however with the infamous economic question of limited resources sustaining unlimited wants is steadily demonstrable through degrading environmental and economic factors thus t strategic aspect of conducting business today involves the need for companies to shoulder responsibility for the environment in which they operate. The movement for environmental protection and consumer rights, using all possible (often extreme) means of communication and pressure is becoming uncompromising and the companies and organizations are

increasingly open to its demands and proposals. A new society arises before our eyes, integrating itself thanks to globalization, development of new technologies and creation of new communication opportunities, around economic and social objectives. A global corporation operating locally becomes a symbol of our times, a person in charge – a symbol of managerial capitalism [96, p. 11].

All managers, whether they like it or not, are responsible for the impact the organization they guide exerts upon the outside world. Therefore a very important task of the managers is to notice and predict the possible influence of their company on society. They should rethink this in a cool and realistic manner, for it is not about finding answers to the question: Are we doing well what we are doing? but: Is whatever we are doing that for which society and the customer pay us?, and Is it consistent with the customers' needs and the needs of their society? [33, p. 88]. Managers should apply the criteria for assessing whether they practice socially responsible business (see Fig. 2). The level of social responsibility has four dimensions; economic, legal, ethical, and ultimately in the attitude known as "unconstrained activity" (often also assisted as a philanthropy) resulting from the need to create and do good.

The success of the company and continuing successful catering for the needs of clients and other participants in the marketing process are associated with maintaining high standards of conduct.
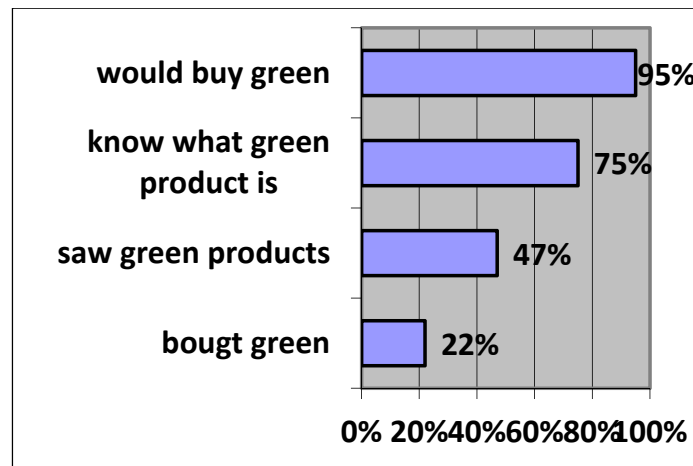
Figure 3. Sustainability shopping trends
(*source: [93]*)

3   Sustainable Marketing - a new trend or necessity

3.1   Global trends

The starting point for the preparation and implementation of effective marketing solutions is understanding the market, as well as the needs of the people, businesses and organizations that form it. Dynamic technological progress constantly brings change among consumers, creates new market solutions, and thus develops the concept of marketing.

The development of computer technology together with globalisation has created a new wave of communication between individuals, and between spontaneously formed groups. This allows for unlimited expression of one's thoughts and ideas, while building global relationships. One of the significant effects of the dominance of information technology is the explosion of social media, which due to their wide availability, low price, and above all, freedom of speech and impartiality now has become the more important approach to marketing communication. While considering the development of information technology, we should emphasize their importance in the development of unrestricted cooperation, providing the ability to simultaneously work on the projects regardless of the distance separating them, through the formation of open source capabilities demonstrated by solutions such as Linux software and the Wikipedia.

A twenty-first century phenomenon of open cooperation is a free forum for exchange of experiences TED - Technology, Entertainment, Design conferences, organized by the U.S. non-profit Sapling Foundation,

and outside the United States – TEDx, x = independently organized TED event - which create an innovative look at the economic, social or cultural reality. Conferences are held in almost every part of the world, and their common mission is to popularize "ideas worth spreading" that can change the world for the better. Today, TED has become a global community, communicating mainly in English but also in more than 50 other languages. It brings together "people from every discipline and culture who seek a deeper understanding of the world" (www.ted.com).

The growing cooperation of consumers using social media and mobile technologies has a great influence on marketing. Marketers are no longer able to fully control messages that create the image of their market offer. Companies more than ever before are forced to cooperate with consumers who are growing in strength. Prospective consumers engage in creating new product and service solutions that will meet their needs, discuss and evaluate the prices, and take part in the assessment and creation of advertising proposals and more increasingly influence strategic change for social good.

Consumers are becoming more active participants in the creation of the sustainable economy, demanding greater transparency over the origin and contents of the goods they consume, and increasingly aware of the broad sustainability challenge facing the world [93]. For example, some 95% of American consumers say they are willing to "buy green" (see Fig. 3) and 44% say their "green" buying habits have not changed, and more than one-third report that they are more likely to buy sustainable products.

The market for products is, in fact, predicted to grow significantly: a recent report for the German government suggests that Germany will earn more money from green products than from car production by 2020 [93, op. cit. p. 14].

3.2   Sustainable Marketing

The underlying notion of marketing is the creation of value by understanding consumer needs, often translated into understanding a given demographic so as to maximise sales and profit. Any drivers towards sustainability could therefore surface if the bottom line would increase accordingly.

Increasingly in recent years companies have been apportioned as the cause of social, environmental and economic problems, leading to crises of a magnitude that is unprecedented in the history of capitalism such as the global financial crisis of 2008, the current East Africa food crisis and the catastrophic oil spills of the past decade. A consequence of decades of business philosophy which sees market activities in a narrow way, primarily through the prism of financial results and conducting business at the expense of society and not for the benefit of society. Moreover, frequent failures to keep promises resulting from previously adopted principles of corporate social responsibility have shaken public confidence in the business and its leaders [91].

Concerns over the fragile state of the globe's natural resources, the damaging consumer footprint on our environment as well as the unbalanced state of world economies have added pressure to sustaining a bottom line vastly dependent on increasing monetary profit. The present situation clearly shows that companies and organizations, and especially their leaders have to rebuild relationships and trust among all participants in the economic scene by proposing a new model of doing business. Thus, the need has arisen to redefine profit with the inclusions of environmental and social revenue and the marketing mix to include the new concept of 'profit' as a foundation.

The underlying philosophy of "Sustainable Marketing", which Kotler calls Marketing 3.0, seems to be a business model that could meet the people's needs, increase the efficiency of the development of global society, create new jobs and raise the level and quality of life for today and tomorrow.

In the first instance, marketers are responsible for promoting sustainable consumption, which was placed as a key challenge for the global community at the Earth Summit in Rio de Janeiro in 1992. Based on three pillars - economic, social and environmental - responsible consumption involves the use of the goods in a more efficient and responsible manner, suggesting an equitable distribution of resources between rich and poor societies [8].

Scientists and educators face the challenge to change the present paradigm, which shows the marketing and responsibility (or, in the broader sense, sustainability) as opposites [60].

Discussion on the essence of marketing and formulation of robust paradigms - especially on the Polish market - which are a source of erroneous assessments of the process is due to an unfortunate identification of marketing with "aggressive sales", advertising, or PR. This interpretation may result from the inconsistent use of the word "marketing" in the Polish translation of the book by Philip Kotler. In some situations, it means the ideal model of market exchange and cooperation, in others - sales and promotion activities. Kotler's intention was obviously to use this term in order to define this ideal model, and not other cases of applying advertising techniques or social influence, devoid of features necessary in marketing: reciprocity, exchange and understanding needs. This interpretation is obvious after a careful reading of his book, as well as other publications on marketing. Not without reason, Kotler's marketing lecture starts from the presentation and critique of sales orientation [65].

Interesting example of the paradigm functioning in Poland is the opinion voiced by Gasparski [47] who, quoting the synthesis of the overview of various aspects of economic life, conducted by the Sociology Committee of the Polish Academy of Science (PAN) from the ethical perspective, talks about the unethical, aggressive and irresponsible marketing, and its impact on shaping people's materialistic personality. The author of this synthesis, Aniela Dylus, writes about the influence of marketing on the formation of human mercantile personality: "[...] a general reflection about the risks associated with marketing, as an essential element of the market, is indirectly related to our situation.

Figure 4. Sustainable marketing development
(*source: self-study*)

Besides, the author of one such analysis, referring to the typology of characters by E. Fromm and R. Funk, points straight out: the syndrome of the marketing character seems [...] very characteristic and topical in the Polish economy in the era of transformation.

Mercantile character includes such features as opportunism, flexibility, mobility, separateness by individualization, coldness due to loss of emotions, selfishness by commercialization. For they allow you to sell well on the personality market, and thus determine your success in life" [47].

Such differences in perception of marketing in Poland create an optional platform for re-definition and education of the newer marketing concept and make clear that the relationship between marketing and sustainability is becoming stronger [60, p. 123] and more necessary.

The Marketing concept conceived as a broadly defined philosophy of action, a way of thinking and doing business, and as a management process that allows individuals and organizations to get what they need and desire to achieve through creating, offering and exchanging products and services of value [71, p. 29] fits in the definition of sustainability.

In Poland, the concept of sustainability is commonly used as *zrównoważony* (stable, balanced) in the areas of development or environment protection (sustainable development, sustainable environmental economy, etc.). This understanding (perhaps it is a matter of translation) significantly limits the concept. Mean-

while, it should be defined much more broadly, as „sustainability is a collective term for everything to do with responsibility for the world in which we live. It is an economic, social and environmental issue. It is about consuming differently and consuming efficiently. It also means sharing between the rich and the poor and protecting the global environment while not jeopardizing the needs of future generations" [60, p. 125].

Sustainable marketing should therefore be seen as marketing, which is a part, but especially a supporting element, of sustainable economic development. Within the framework of sustainable development, marketing has undergone a three-step evolution [58] (see Fig. 4). The first phase dates back to the 1970s: ecological marketing, focusing on ecological problems, such as air and water pollution, depletion of natural resources, and environmental impact of fertilizers and pesticides used in agriculture. The second stage is the 1980s: environmental marketing, focused on developing modern, environmentally friendly "clean" technologies. In the center of marketing activities was "green customer segment", seeing the responsible action as a competitive advantage. The third stage is the current era of sustainable marketing, which aims at responsible economic and social development.

Sustainable marketing focuses on meeting the needs of today's consumer but moreover including the next generations of consumers and the possibility of meeting their needs. Sustainable marketing is also seen as a philosophy with a goal to bring together participants in the market, social activists and organizations whose
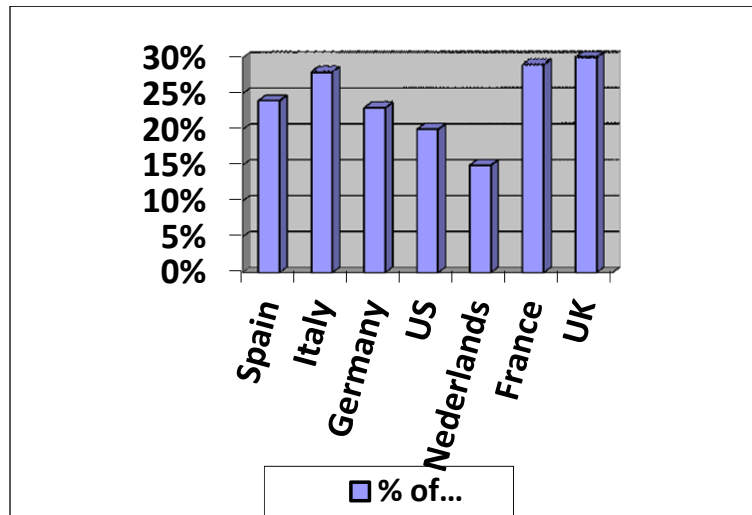
Figure 5. % of population that purchase sustainable brands
(*source [113]*)

interests have not coincided so far, in order to create a common worldview through the prism of the responsibility for protecting and preserving the environment, social responsibility and wise management of global financial resources.

The research conducted on European most advanced markets in terms of implementation of sustainability, as well as in US, shows that responsible customers require action from marketers. There is a growing pressure on business and marketing leaders to be concerned about society and at the same time about their own families, lifestyles and professional legacies and act to insure that this is no passing fad [114].

The marketing professionals as influencers, communicators and shapers of culture, have abilities to ensure that they make a significant difference both to their customers and the environment. In practice they have been looking at the products and/or services, assessing how they impact the environment and then taking actions to minimize those negative impacts.

Customers are looking for brands they feel have commitments to environmental and social issues and "they are voting with their wallets" (see Fig. 5).

Kevin Roberts CEO Worldwide of Saatchi & Saatchi stated: "Every client sees sustainability as a priority issue and every employee and customer wants to be part of a bigger idea. No brand will be truly loved by anyone it touches unless it shares an inspired, sustainable benefit" [114, op. cit. p. 10].

The most effective campaigns to encourage ethical consumption are those that take place at a collective level, such as the creation of Fair Trade offers (see Fig. 6), rather than those that target individual behavior.

Figure 6. International logo of Fair Trade influencing ethical consumption.
(s*ource:http://thesituationist.wordpress.com/2007/08/16/the-situation-of-ethical-consumption/*)
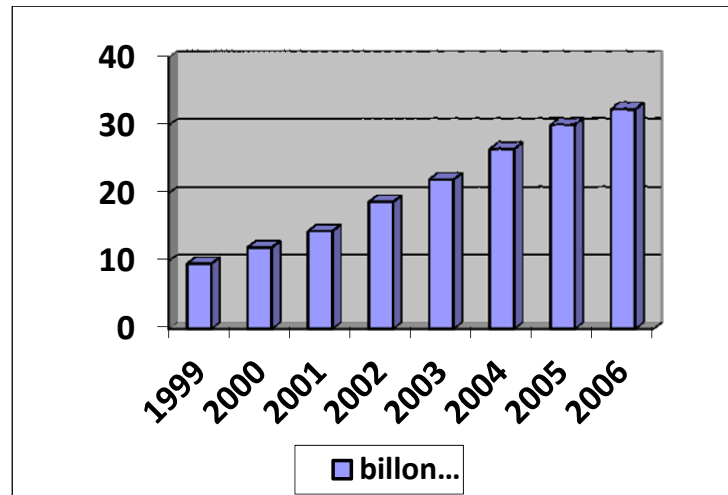
Figure 7. Customer spending on ethical consumption in UK
(*source: [113]*)
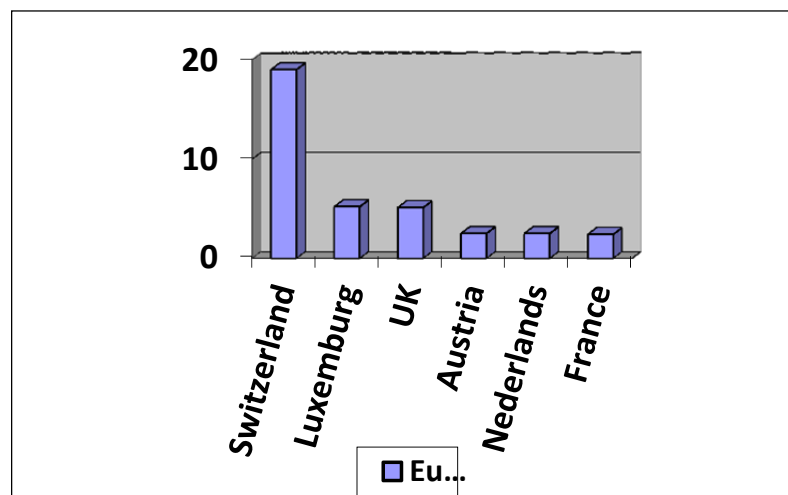
Figure 8. Average consumption of Fair Trade Products per capita
(s*ource: [113]*)

According to the Ethical Consumption and Fair Trade Fundation Reports [113, op. cit. p. 10] in Europe, favorable attitudes towards sustainable purchasing are becoming widespread (see Fig. 5). Value of ethical spending in the UK for example grown 9% in 12 months (2006-2006) to 32,3 billion GBP (see Fig. 7), while sales of Fair Trade products in the UK grew by a staggering 81% from 2006 to 2007.

Fair Trade is also a barometer of consumer attitudes to ethical consumption and sustainability. Fig. 8 demonstrates that average per capita consumption of Fair Trade products in Europe is becoming economically significant.

4   Summary

Today's economy is experiencing serious economic and social problems affecting all citizens of the world, both rich and poor. The earth seems to become insufficient to meet the standards of living that the developed societies expect.

Marketing is seen as the cause of many such problems. It contributed to the emergence of the behaviors that should be changed. With its indisputable impact on market development, marketing has a strong influence on degradation, but it can also build positive behaviors of consumers, enterprises, organizations, and entire societies. Understood as a philosophy of action, a way of thinking and doing business, sustainable marketing promotes credibility and responsi-

bility, leading to better consumption, better relationships, and more responsible business, thus influencing the creation of a better world.

Sustainable marketing is not just about producing better and cheaper, and refrain from cutting down trees. This is a genuine practical value of doing business, which influences efficiency, inspires creativity, promotes and preserves cooperation. Thanks to balancing the needs of people, global environment and economic development in the long run, sustainable marketing provides businesses and organizations with faith and strength to create "more" while using less funds and resources.

On an operational level, sustainable marketing aims to influence customer behavior and utilise consumer social evolution in order to create positive social change and thus to achieve a new long-term profit. It is also meant to influence what the customer receives - create brands that are part of the commercial and social future. Finally, it is supposed to provide goods and services, through managing in a responsible manner, being open to fair cooperation in marketing communication.

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OPTIMIZATION MODEL FOR MULTIMODAL TRANSPORTATION NETWORKS BASED ON SUPPLY CHAIN

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Abstract: The article presents the problem of supply chain optimization from the perspective of a multimodal logistics provider and includes a mathematical model of multilevel cost optimization in the form of MILP (Mixed Integer Linear Programming). The costs of production, transport, distribution and environmental protection were adopted as optimization criteria. Timing, volume, capacity and mode of transport were also taken into account. The model was implemented in the LINGO ver.12. The numerical experiments were carried out using sample data to show the possibilities of practical decision support and supply chain optimization.

Keywords: supply chain, multimodal logistics, MILP, decision support, optimization.

1 Introduction

A supply chain is a concept in the area of science and practice that has been strongly developing since the '80s of the last century. Numerous definitions describe the term, and a supply chain reference model has also been designed ([6], [19] and [20]). A supply chain is commonly seen as a collection of various types of companies (raw materials, production, trade, logistics, etc.) working together to improve the flow of products, information and finance. As the words in the term indicate, it is a combination of the chain's individual links in the process of supplying products (material and services) to the market.

The idea of the supply chain dates back to the early '80s of the past century when it was used as an alternative way to assess the relationship between suppliers and customers in the market previously perceived as an arena of ongoing hostilities and taking advantage of the position in the market for benefits and synergy effect.

Initially, a supply chain was a remedy adopted for reducing a company's, supplier's and customer's inventory levels. Currently, attention is being drawn to integration and synchronization of activities within the supply chain, and its automation through IT solutions and multimodal environments.

Supply-chain problems fall into three categories:

- supply-chain infrastructure (network) design and strategy,
- supply-chain planning,
- supply-chain operations and execution.

The first two categories are essentially offline activities associated with establishing the best way to configure and manage the supply-chain network. The third category involves decisions on how to operate the network to choose best response to the external conditions faced by the supply chain (online decision).

The article presents the problem of outsourcing logistics management in supply chain with multimodal network environment and a mathematical model of supply chain optimization in multimodal environment as an integer linear programming problem [12]. This model can be the basis for the decision support in the supply chain management.

The application of the model will allow answering many decision questions such as: How to realize customers' orders at the best price? How will they look at the time of delivery? Which distributors will take part in the supply? Do distributors have sufficient capacity to carry out the orders? What is the level of utilization of capacity distributors? There can be many more of such questions.

As you can see, the results of the optimization of the presented model can be the basis for the decision support (both offline and online).

The complexity and flexibility of the presented model as well as the manner of its implementation are the main achievements and contributions of the article. An additional achievement is the formulation of the model in the form of integer linear programming, which facilitates its use in the practical aspects.
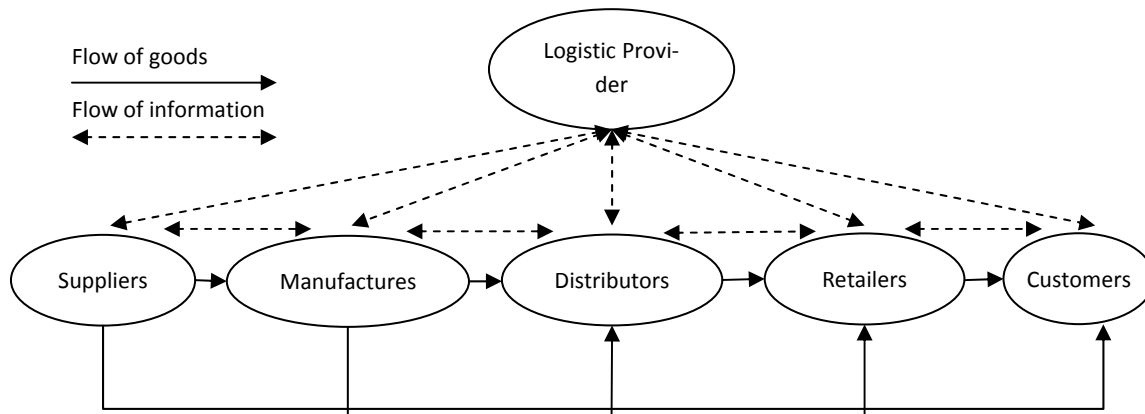
Figure 1. The chart of the supply chain with logistics services outsourced to a logistic provider
(*source: own work*)

This is due to the availability of multiple environments solving this class of models like LINGO, CPLEX.

Very interesting is also the proposal to introduce a new class of decision variables at the implementing level. These variables allow making a deeper analysis of the obtained solutions being transparent to the model, not complicating it further.

2 Supply Chain Management

The aim of supply chain management (SCM) is to increase sales, reduce costs and take full advantage of business assets by improving interaction and communication between all the actors forming the chain. The supply chain management is a decision process that not only integrates all of its participants but also helps to coordinate the basic flows: products/services, information and funds. Changes in the global economy and the increasing globalization lead to the widespread use of IT tools, which enable continuous, real-time communication between the supply chain links. One of the objectives is to optimize logistics and entrust it to specialized companies.

This trend contributed to the development of logistics outsourced operators known as 3PL, 4PL, or 5PL. The term 3PL (Third Party Logistics) refers to the use of external companies and organizations to carry out logistic functions that can involve the entire logistics process or its selected features. The company offers and provides 3PL services using its own means of transport, warehouses, equipment and other necessary resources, and acts as a "third party" between

a producer and a customer. The resulting model with the supply chain logistics services outsourced to specialized 3LP companies is shown in Fig. 1. This kind of cooperation is frequently referred to as the logistics alliance.

4PL (Fourth Party Logistics) is a certain evolution of the 3PL concept to provide greater flexibility and adaptation to the needs of the client. 4PL companies and organizations operate primarily by managing the information flow within the entire supply chain. A 4PL coordinates logistics processes along the whole length of the chain (from raw materials to end-buyers) not being limited only to the selected segment as is the case with a 3PL. The 4PL model enables the 3PL operator to become a coordinator and integrator of the flows, not just an operator of physical movement of goods. Very often, its subcontractors are 3PL or even 2PL (Second Party Logistics) operators, i.e., transport companies and warehouses. A company that uses the services of a 4PL provider is in contact with only one operator who manages and integrates all types of resources and oversees the entire functionality across the supply chain. 4PL providers, having a complete picture of the supply chain and large IT capabilities may offer optimization and decision support advisory services. Further development of logistics outsourcing resulted in the creation of 5LP model (Fifth Party Logistics) - providers of integrated logistics services that can design and implement flexible and networked supply chains with multimodal environments to cater to the needs of all participants (manufacturers, suppliers, carriers and end users) [18].
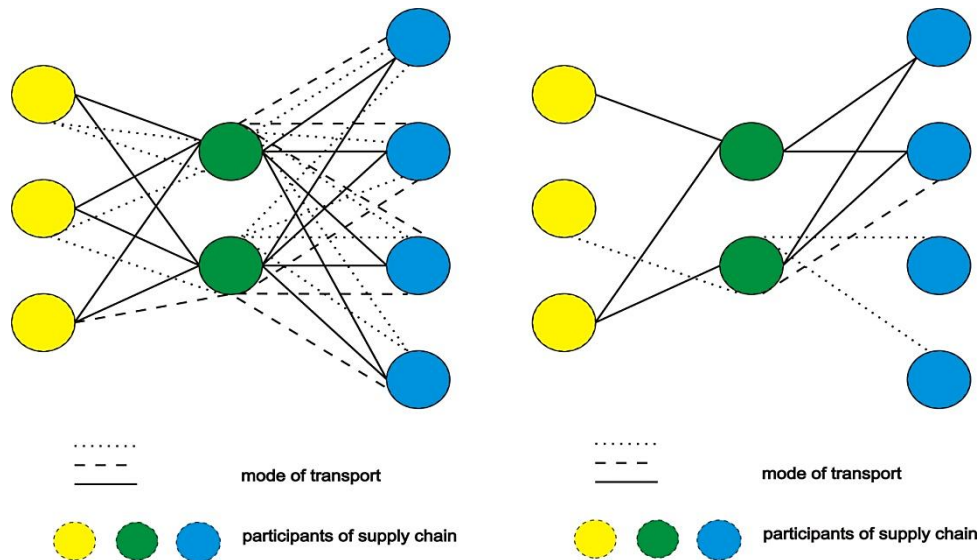
Figure 2. The part of supply chain network including multimodal transport
(*source: own work*)

3 Mode of transport in Supply Chain

Many logistic providers have or use multimodal transportation systems. Transportation system is multimodal when the infrastructure supports various transportation modes, such as truck, rail, air, and ocean/river navigation, and carriers operating and offering transportation services on these modes. International multimodal transport is a logistic concept that covers the movements of goods from a supplier to a receiver under the responsibility of a single transport operator. It represents the flow of goods, where at least on one part of the transport chain, two different modern mode of transport are involved at the same time.

Currently, most of the logistics is or uses the services of MTO (Multimodal Transport Operator- organizes and is responsible for the whole transport chain on the basis of one multimodal contract).

A model of supply chain network of multimodal transport is shown in Fig. 2. The chart on the left shows all the acceptable modes of transport between the participants in the supply chain. The chart on the right shows the optimal or feasible configuration of the transport for a given set of customer orders.

4 Motivation

Simultaneously considering the supply chain production, distribution processes in distribution centers and transport-planning problems greatly advances the efficiency of all processes. The literature in the field is vast, so an extensive review of existing research on the topic is extremely helpful in modeling and research. Comprehensive surveys on these problems and their generalizations were published, for example, in [9].

In our approach, we are considering a case of the supply chain where:

- the shared information process [9] in the supply chain consists of resources (capacity, versatility, costs), inventory (capacity, versatility, costs, time), production (capacity, versatility, costs), product (volume), transport (cost, mode, time), demand, etc.,
- the transport is multimodal (several modes of transport, limited number of means of transport for each mode),
- different products are combined in one batch of transport,
- the cost of supplies is presented in the form of a function (in this approach linear function of fixed and variable costs) ([11], [15], [14], [10] and [16]),
- different decision levels are considered simultaneously,
- the environmental aspects of use of transport modes (depend on the use of fossil fuels and carbon-dioxide emissions etc.).
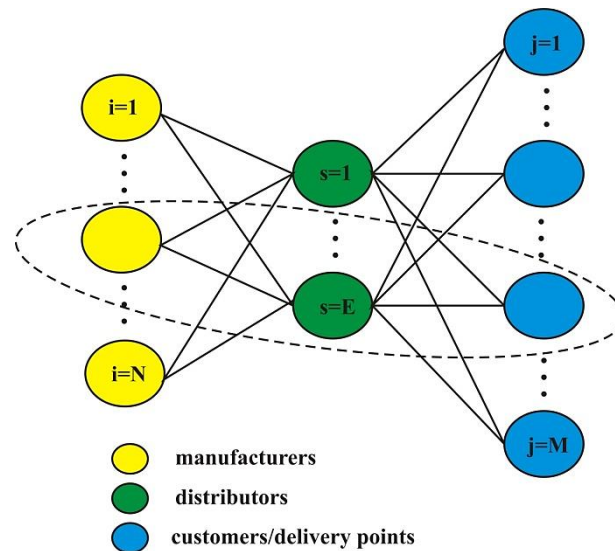
Figure 3. The part of the supply chain network with marked indices of individual participants (elements).
Dashed line marks one of the possible routes of delivery. Relationships between the participants are multimodal
(*source: own work*)

Therefore, the motivation behind this work [9] is to suggest an approach to decision support in the supply chain that can provide decision support at various levels of decision-making, taking into account the many types of constraints (time, capacity, environment etc.). The proposed approach will be a demand-driven model. The aim of this paper is to design and implement the model that can become the basis for making optimal decisions at different levels of supply chain management. The proposed solution will also enable a comprehensive examination of the impact on cost and performance of various parameters of the shared information. An important feature of the proposed model is its multimodality. It occurs at different levels of detail. On the one hand, the model includes multimodal transport and on the other constraints of the model are different types (modes). There are resource constraints, time constraints, capacity constraints, space and environment constraints.

5   Mathematical model

For the supply chain network model (see Fig. 3) with multimodal transport (see Fig. 2), an optimization model was proposed, designed from a perspective of logistic /MTO providers. The mathematical optimization model was formulated as an integer linear programming problem ([17], [25]) with the minimization of costs (1) under constraints (2)..(24). Indices, parameters and decision variables in the model together with

their descriptions are provided in Table 1. The proposed optimization model is a cost model that takes into account two other types of parameters, i.e., the spatial parameters (are/ volume occupied by the product, specified by the distributor) and time (duration of delivery and service by distributor, etc.). The position of each parameter against the subsequent links of the supply chain is shown in Fig. 4. The objective function (1) defines the aggregate costs of the entire chain and consists of five elements. The first is the fixed costs associated with the operation of the distributor involved in the delivery (e.g. distribution center, warehouse, etc.). The second part sets out the environmental costs of using various means of transport. They are dependent on the one hand the number of courses the means of transport, the other from the environmental levy, which may depend on the use of fossil fuels and carbon-dioxide emissions.

The third component determines the cost of supply from the manufacturer to the distributor. Another component is responsible for the costs of supply from the distributor to the end user (the store, the individual client, etc.). The last component of the objective function determines the cost of manufacturing the product by the given manufacturer. The model was developed with the constraints (2)..(24).

Constraint (2) specifies that all deliveries of product k produced by the manufacturer i and delivered to all distributors s using mode of transport d do not exceed the manufacturer's production capacity.
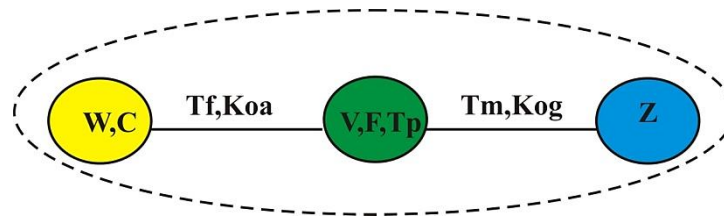
Figure 4. The selected path of the supply chain along with the parameters that describe the individual elements and their dependencies
(*source: own work*)

Table 1. Summary indices, parameters and decision variables of the mathematical optimization model
(*source: own work*)

Indices			
Symbol	Description	Symbol	Description
k	product type (k = 1..O)	N	number of manufacturers/factories
j	delivery point/customer/city (j = 1..M)	M	number of delivery points/customers
i	manufacturer/factory (i = 1..N)	E	number of distributors
s	distributor /distribution center (s = 1..E)	O	number of product types
d	mode of transport (d = 1..L)	L	number of mode of transport
Input parameters			
Symbol	Description		
F_s	the fixed cost of distributor/distribution center s (s = 1..E)		
P_k	the area/volume occupied by product k (k = 1..O)		
V_s	distributor s maximum capacity/volume (s = 1..E)		
$W_{i,k}$	production capacity at factory i for product k (i = 1..N) (k = 1..O)		
$C_{i,k}$	the cost of product k at factory i (i = 1..N) (k = 1..O)		
$R_{s,k}$	if distributor s (s = 1..E) can deliver product k (k = 1..O) then R_{sk} = 1, otherwise R_{sk} = 0		
$Tp_{s,k}$	the time needed for distributor s (s = 1..E) to prepare the shipment of product k (k = 1..O)		
$Tc_{j,k}$	the cut-off time of delivery to the delivery point/customer j (j = 1..M) of product k (k = 1..O)		
$Z_{j,k}$	customer demand/order j (j = 1..M) for product k (k = 1..O)		
Zt_d	the number of transport units using mode of transport d (d = 1..L)		
Pt_d	the capacity of transport unit using mode of transport d (d = 1..L)		
$Tf_{i,s,d}$	the time of delivery from manufacturer i to distributor s using mode of transport d (I = 1..N) (s = 1..E) (d = 1..L)		
$K1_{i,s,k,d}$	the variable cost of delivery of product k from manufacturer i to distributor s using mode of transport d (d = 1..L) (i = 1..N) (s = 1..E) (k = 1..O)		
$R1_{i,s,d}$	if manufacturer i can deliver to distributor s using mode of transport d then $R1_{isd}$ = 1, otherwise $R1_{isd}$ = 0 (d = 1..L) (s = 1..E) (i = 1..N)		
$A_{i,s,d}$	the fixed cost of delivery from manufacturer i to distributor s using mode of transport d (d = 1..L) (i = 1..N) (s = 1..E)		
$Koa_{i,s,d}$	the total cost of delivery from manufacturer i to distributor s using mode of transport d (d = 1..L) (i = 1..N) (s = 1..E)		
$Tm_{s,j,d}$	the time of delivery from distributor s to customer j using mode of transport d (d = 1..L) (s = 1..E) (j = 1..M)		
$K2_{s,j,k,d}$	the variable cost of delivery of product k from distributor s to customer j using mode of transport d (d = 1..L) (s = 1..E) (k = 1..O) (j = 1..M)		
$R2_{sjd}$	if distributor s can deliver to customer j using mode of transport d then $R2_{sjd}$ = 1, otherwise $R2_{s,j,d}$ = 0 (d = 1..L) (s = 1..E) (j = 1..M)		
$G_{s,j,d}$	the fixed cost of delivery from distributor s to customer j using mode of transport d (s = 1..E) (j = 1..M) (k = 1..O)		
$Kog_{s,j,d}$	the total cost of delivery from distributor s to customer j using mode of transport d (d = 1..L) (s = 1..E) (j = 1..M) (k = 1..O)		
Od_d	the environmental cost of using mode of transport d (d = 1..L)		

Table 2. Summary indices, parameters and decision variables
of the mathematical optimization model (continued)
(*source: own work*)

Decision variables	
Symbol	Description
$X_{i,s,k,d}$	delivery quantity of product k from manufacturer i to distributor s using mode of transport d
$Xa_{i,s,d}$	if delivery is from manufacturer i to distributor s using mode of transport d then $Xa_{i,s,d} = 1$, otherwise $Xa_{i,s,d} = 0$
$Xb_{i,s,d}$	the number of courses from manufacturer i to distributor s using mode of transport d
$Y_{s,j,k,d}$	delivery quantity of product k from distributor s to customer j using mode of transport d
$Ya_{s,j,d}$	if delivery is from distributor s to customer j using mode of transport d then $Ya_{s,j,d} = 1$, otherwise $Ya_{s,j,d} = 0$
$Yb_{s,j,d}$	the number of courses from distributor s to customer j using mode of transport d
Tc_s	if distributor s participates in deliveries, then $Tc_s = 1$, otherwise $Tc_s = 0$
CW	arbitrarily large constant

Constraint (3) covers all customer j demands for product k ($Z_{j,k}$) through the implementation of supply by distributors s (the values of decision variables $Y_{i,s,k,d}$). The constraint was designed to take into account the specificities of the distributors resulting from environmental or technological constraints (i.e., whether the distributor s can deliver the product k or not). The balance of each distributor s corresponds to constraint (4). The possibility of delivery in due to its technical capabilities - in the model, in terms of volume /capacity of the distributor's is defined by constraint (5). Constraint (6) ensures the fulfillment of the terms of delivery time. Constraints (7), (8), (9) guarantee deliveries with available transport taken into account. Constraints (10), (11), (12) respectively set values

of decision variables based on binary variables Tc_s, $Xa_{i,s,d}$, $Ya_{s,j,d}$. Dependencies (13) and (14) represent the relationship by which total costs are calculated. In general, these may be any linear functions. The remaining constraints (15)...(24) arise from the nature of the model (MIP- mixed integer linear programming).

In this model the cost of supplies Koa (13), Kog (14) is presented in the form of a function. This could be any function with various parameters. In the present version of the model, they are linear functions whose values depend on such supplied products, distance and mode of transport.

The objective function - minimization of costs

$$\sum_{s=1}^{E} F_s * Tc_s + \sum_{d=1}^{L} Od_d (\sum_{i=1}^{N}\sum_{s=1}^{E} Xb_{i,s,d} + \sum_{s=1}^{E}\sum_{j=1}^{M} Yb_{j,s,d})$$
$$+ \sum_{i=1}^{N}\sum_{s=1}^{E}\sum_{d=1}^{L} Koa_{i,s,d} + \sum_{s=1}^{E}\sum_{j=1}^{M}\sum_{d=1}^{L} Kog_{s,j,d} + + \sum_{i=1}^{N}\sum_{k=1}^{O}(C_{ik} * \sum_{s=1}^{E}\sum_{d=1}^{L} X_{i,s,k,d})$$

(1)

subject to:

$$\sum_{s=1}^{E}\sum_{d=1}^{L} X_{i,s,k,d} \leq W_{i,k} \text{ for } i = 1..N, k = 1..O$$

(2)

$$\sum_{s=1}^{E}\sum_{d=1}^{L}(Y_{s,j,k,d} * R_{s,k}) \geq Z_{j,k} \text{ for } j = 1..M, k = 1..O$$

(3)

$$\sum_{i=1}^{N}\sum_{d=1}^{L} X_{i,s,k,d} = \sum_{j=1}^{M}\sum_{d=1}^{L} Y_{s,j,k,d} \text{ for } s = 1..E, k = 1..O$$

(4)

$$\sum_{k=1}^{O}(P_k * \sum_{i=1}^{N}\sum_{d=1}^{L} X_{i,s,k,d}) \leq Tc_s * V_s \text{ for } s = 1..E$$

(5)

$$Xa_{i,s,d} * Tf_{i,s,a} + Xa_{i,s,d} * Tp_{s,k} + Ya_{s,j,d} * Tm_{s,j,d} \leq Tc_{j,k}$$
$$\text{for } i = 1..N, \ s = 1..E, \ j = 1..M, \ k = 1..O, d = 1..L \tag{6}$$

$$R1_{i,s,d} * Xb_{i,s,d} * Pt_d \geq X_{i,s,k,d} * P_k \ \text{for } i = 1..N, s = 1..E, k = 1..O, d = 1..L \tag{7}$$

$$R2_{s,j,d} * Yb_{s,j,d} * Pt_d \geq Y_{s,j,k,d} * P_k \ \text{for } s = 1..E, \ j = 1..M, \ k = 1..O, d = 1..L \tag{8}$$

$$\sum_{i=1}^{N}\sum_{s=1}^{E} Xb_{i,s,d} + \sum_{j=1}^{M}\sum_{s=1}^{E} Yb_{j,s,d} \leq Zt_d \ \text{for } d = 1..L \tag{9}$$

$$\sum_{i=1}^{N}\sum_{d=1}^{L} Xb_{i,s,d} \leq CW * Tc_s \ \text{for } s = 1..E \tag{10}$$

$$Xb_{i,s,d} \leq CW * Xa_{i,s,d} \ \text{for } i = 1..N, s = 1..E, d = 1..L \tag{11}$$

$$Yb_{s,j,d} \leq CW * Ya_{s,j,d} \ \text{for } s = 1..E, j = 1..M, d = 1..L \tag{12}$$

$$Koa_{i,s,d} = A_{i,s,d} * Xb_{i,s,d} + \sum_{k=1}^{O} K1_{i,s,k,d} * X_{i,s,k,d} \ \text{for } i = 1..N, s = 1..E, d = 1..L \tag{13}$$

$$Kog_{s,j,d} = G_{s,j,d} * Yb_{j,s,d} + \sum_{k=1}^{O} K2_{s,j,k,d} * Y_{s,j,k,d} \ \text{for } s = 1..E, j = 1..M, d = 1..L \tag{14}$$

$$X_{i,s,k,d} \geq 0 \ \text{for } i = 1..N, s = 1..E, k = 1..0, \ d = 1..L \tag{15}$$

$$Xb_{i,s,d} \geq 0 \ \text{for } i = 1..N, \ s = 1..E, \ d = 1..L \tag{16}$$

$$Yb_{s,j,d} \geq 0 \ \text{for } s = 1..E, \ j = 2..M, \ d = 1..L \tag{17}$$

$$X_{i,s,k,d} \in C \ \text{for } i = 1..N, s = 1..E, \ k = 1..0, d = 1..L \tag{18}$$

$$Xb_{i,s,d} \in C \ \text{for } i = 1..N, \ s = 1..E, \ d = 1..L \tag{19}$$

$$Y_{s,j,k,d} \in C \ \text{for } s = 1..E, j = 1..M, \ k = 1..0, d = 1..L \tag{20}$$

$$Yb_{s,j,d} \in C \ \text{for } s = 1..E, \ j = 1..M, \ d = 1..L \tag{21}$$

$$Xa_{i,s,d} \in \{0,1\} \ \text{for } i = 1..N, s = 1..E, \ j = 1..M, \ d = 1..L \tag{22}$$

$$Ya_{s,j,d} \in \{0,1\} \ \text{for } s = 1..E, \ j = 1..M, \ d = 1..L \tag{23}$$

$$Tc_s \in \{0,1\} \ \text{for } s = 1..E \tag{24}$$

6   Implementation of the model

The model was implemented in LINGO environment designed by LINDO Systems [8]. LINGO Optimization Modeling Software is a powerful tool for building and solving mathematical optimization models. The LINGO package provides the language to build optimization models and the editor program including all the necessary features and built-in "solvers" in a single integrated environment. It is designed to model and solve linear, nonlinear, quadratic, integer and stochastic optimization problems. Model implementation is possible in two basic ways. The first way is to enter the model into the LINGO editor in the explicit form, that is, a full function of the objective with all the constraints, parameters, etc. Although this approach is intuitive and consistent with the standard form of linear programming [17], it is not very useful in practice. This is due to the size of models implemented in practice. For the examples presented in "Computational Examples" chapter, the number of decision variables and constraints was 451 and 863, respectively. The other way is to use the LINGO language of mathematical modeling (implicit form), an integral part of the LINGO package, whose basic syntax elements are shown in Table 2.

Table 2. The set of tables with numerical data for example P1, P2, P3

Mathematical nomenclature	LINGO syntax
Minimum	MIN =
$\sum Z_{ikt}$	@sum(ORDER (j,k,t))
j=1..M for each customer (j) in the set of customers	@FOR(CUSTOMERS (j))
●	*
=	=
$X \in$ integer	@gin(X)
$X \in \{0,1\}$	@bin(X)
Load input parameters p from the file dane.ldt	p=@file(dane.ldt)

For real examples with sizes exceeding several decision variables, the construction and implementation of the model is only possible using the modeling language (see Listing 1).

The basic elements of LINGO mathematical modeling language syntax are presented in Table 2. The model can be saved as a text file using any text editor and with a standard extension *. lng and *. ldt data file. The structure of the model is composed of sections. The main section is the MODEL section, which begins with the word MODEL: and ends with the word END. Other sections may be integrated in this section. The most important sections, highlighted by the relevant keywords are: section SETS (SET: ENDSETS) and DATE (DATE: enddate). In the SETS section you can define types of simple or complex objects and their mutual relationships. In the implemented model, types such as products, factories, etc. correspond to simple objects; complex objects cover production, distribution, etc. In this section, the parameters and variables of the model are assigned to particular types. DATA section allows initiating or assigning values to individual parameters of the model. There are two methods to do it in the LINGO package: either place numerical data directly in the section or make references to the place where those data files are included. This method of model construction ensures the separation of data from the relevant model, which is very important because the change in data values or even their size does not require any changes in the objective function or constraints. Only the model implemented in the implicit form has such a feature.

Listing 1. Implementation of the mathematical model in LINGO package

```
! k - product type                    O = 5;
! j - customers                       M = 4;
! i - factory                         N = 2;
! s - distributor                     E = 3;
! t - period                          H = 10;
! d - mode                            L = 4;
Model:
 Sets:
     products              /1..@file(rozmiary.ldt)/:p;
     factory               /1..@file(rozmiary.ldt)/;
     customers             /1..@file(rozmiary.ldt)/;
     distributors          /1..@file(rozmiary.ldt)/:f,v,vx,T;
     mode                  /1..@file(rozmiary.ldt)/:pt,zt,od,dx;
     order                 (customers,products):z,tc;
     production            (factory,products):c,w,wx;
     location              (distributors,products):r,tp;
     supplies_mode_1       (factory,distributors,mode):a,r1,tf,Xb,Xa,ko_1;
     supplies_mode_2       (distributors,customers,mode):g,r2,tm,Yb,Ya,ko_2;
     supp_mode_1           (factory,distributors,products,mode):X,k1;
     supp_mode_2           (distributors,customers,products,mode):Y,k2;
     supp_period_1         (factory,distributors,products);
     supp_period_2         (distributors,customers,products);

 EndSets
Data:
 p  =@file(dane.ldt);
 f  =@file(dane.ldt);
 v  =@file(dane.ldt);
 pt =@file(dane.ldt);
 zt =@file(dane.ldt);
 z  =@file(dane.ldt);
```

Listing 1. Implementation of the mathematical model in LINGO package (continued)

```
 tc =@file(dane.ldt);
 c  =@file(dane.ldt);
 w  =@file(dane.ldt);
 r  =@file(dane.ldt);
 tp =@file(dane.ldt);
 a  =@file(dane.ldt);
 r1 =@file(dane.ldt);
 tf =@file(dane.ldt);
 g  =@file(dane.ldt);
 r2 =@file(dane.ldt);
 tm =@file(dane.ldt);
 k1 =@file(dane.ldt);
 k2 =@file(dane.ldt);
 od =@file(dane.ldt);
 sta=@file(dane.ldt);
EndData
! Goal function;
Min=        @sum(distributors(s):f(s)*T(s))+
    @sum(supp_mode_1(i,s,k,d):ko_1(i,s,d)) +
    @sum(supp_mode_2(s,j,k,d):ko_2(s,j,d)) +
    @sum(production(i,k):c(i,k)*(@sum(distributors(s):@sum(mode(d):X(i,s,k,d) ))))+
    @sum(mode(d):od(d)*            (@sum(factory(i):@sum(distributors(s):Xb(i,s,d)))            +
@sum(distributors(s):@sum(customers(j):Yb(s,j,d)))));

@for(supplies_mode_1(i,s,d):
    ko_1(i,s,d)=a(i,s,d)*Xb(i,s,d)+@sum(products(k):k1(i,s,k,d)*X(i,s,k,d))
    );

@for(supplies_mode_2(s,j,d):
    ko_2(s,j,d)=g(s,j,d)*Yb(s,j,d)+@sum(products(k):k2(s,j,k,d)*Y(s,j,k,d))
    );


! Constraint-production capacity ;
   @for(production(i,k):
   @sum(distributors(s):@sum(mode(d): X(i,s,k,d))) <=w(i,k) ;
   @sum(distributors(s):@sum(mode(d): X(i,s,k,d))) =wx(i,k) ;
   );

! Constraint-customer orders;
  @for(order(j,k):
    @sum(distributors(s):@sum(mode(d): r(s,k)*Y(s,j,k,d))) >=z(j,k)
  );

! Constraint- balance of distributors;
 @for(distributors(s):
    @for(products(k):
                  @sum(factory(i):@sum(mode(d):X(i,s,k,d)))                          =
@sum(customers(j):@sum(mode(d):Y(s,j,k,d)))
      )
 );
! Constraint-distributors capacity;
 @for(distributors(s):
    @sum(products(k):
                  p(k)*@sum(factory(i):@sum(mode(d):X(i,s,k,d)))
          ) <=T(s)*v(s);
    @sum(products(k):
                  p(k)*@sum(factory(i):@sum(mode(d):X(i,s,k,d)))
          ) <=vx(s);
 );
! Constraint-time of delivery;
 @for(order(j,k):
   @for(distributors(s):
     @for(mode(d):
        @for(factory(i):
           Xa(i,s,d)*tf(i,s,d)+Xa(i,s,d)*tp(s,k)+Ya(s,j,d)*tm(s,j,d)<=tc(j,k)
                 )
     )
   )
 );

! Constraint- mode of transport;
 @for(supp_mode_1(i,s,k,d):
    r1(i,s,d)*Xb(i,s,d)*pt(d)>=X(i,s,k,d)*p(k)
```

Listing 1. Implementation of the mathematical model in LINGO package (continued)

```
    );
 @for(supp_mode_2(s,j,k,d):
    r2(s,j,d)*Yb(s,j,d)*pt(d)>=Y(s,j,k,d)*p(k)
    );
! Constraint- the number of units ;
 @for(mode(d):
    @sum(factory(i):@sum(distributors(s):Xb(i,s,d)))              +
@sum(distributors(s):@sum(customers(j):Yb(s,j,d)))  <=zt(d);
    @sum(factory(i):@sum(distributors(s):Xb(i,s,d)))              +
@sum(distributors(s):@sum(customers(j):Yb(s,j,d)))  = dx(d);


 );
! Constraint-distributors;
 @for(distributors(s):
  @sum(factory(i):@sum(mode(d):Xb(i,s,d)))<=T(s)*Sta
 );

 @for(supplies_mode_1(i,s,d): Xb(i,s,d)<=Xa(i,s,d)*Sta);
 @for(supplies_mode_2(s,j,d): Yb(s,j,d)<=Ya(s,j,d)*Sta);

 @for(supplies_mode_1(i,s,d): Xb(i,s,d)>=Xa(i,s,d));
 @for(supplies_mode_2(s,j,d): Yb(s,j,d)>=Ya(s,j,d));

! Constraints-binary and integer;
 @for(distributors(s):
    @bin(T(s))
 );
 @for(supp_mode_1(i,s,k,d):
    @gin(X(i,s,k,d));
    @gin(Xb(i,s,d));
      @bin(Xa(i,s,d));
 );
 @for(supp_mode_2(s,j,k,d):
    @gin(Y(s,j,k,d));
    @gin(Yb(s,j,d));
      @bin(Ya(s,j,d));
 );

End
```

7   Computational examples

The mathematical model (1)..(24) was implemented in the LINGO environment. All acceptable modes of transport among the participants in the supply chain for the computational examples are in Fig. 5. For clarity, all possible modes of transport are presented in separate diagrams.

Optimization was performed for examples: P1 to P7. All examples relate to the supply chain in which there are two manufacturers (I = 1..2), three distributors (s = 1..3), four recipients (j = 1..4), five types of products (k = 1..5), three modes of transport (d = 1..3).

The examples differ in capacity available to the distributors (V_s) and the environmental cost of using mode of transport d (Od_d). The numerical data for all the model parameters from Table 1 are presented in Table 3.

Decision variables of the model are directly or indirectly related to the mode of delivery (customer orders) for operational decisions. These decisions refer to proper volume supply of particular products and the number of runs in a specific mode of transport.

Full list of non-zero decision variables which optimize the objective function (Fc = 37820), for example, P1 is shown in Table 4. Fig. 6 illustrates that the modes of transport have been selected for various routes for the optimal solution. On the basis of these results it is possible to draw conclusions about the structure of the supply chain and transportation. Decisions resulting from the conclusions are long-term decisions concerning, for instance, distribution capacity, production capacity etc. For further studies and especially long-term decision support, the optimization model was extended in the implementation stage. To better support this type of decision, the authors have introduced additional decision variables which do not affect the value of the objective function nor make the mathematical model more complicated. The variables were introduced only at the implementing level. LINGO system ensures such possibilities. Three new decision variables

were introduced: Wx_{ik} (level of capacity utilization for the product k the factory i), Vx_s (capacity/volume utilization for distributor s) and Dx_d (total number of courses of transport mode d). Sample values of implementation decision variables Vx_t, Wx_{ikt}, Dx_d for example P1 are presented in Table 4.

Due to the size, detailed results of the optimization (non-zero values for all decision variables) are shown only for example P1. For examples from P2 to P7 only the result of optimization is shown, i.e. the value of the objective function and the corresponding multi-modal network (see Fig. 7 to 12).
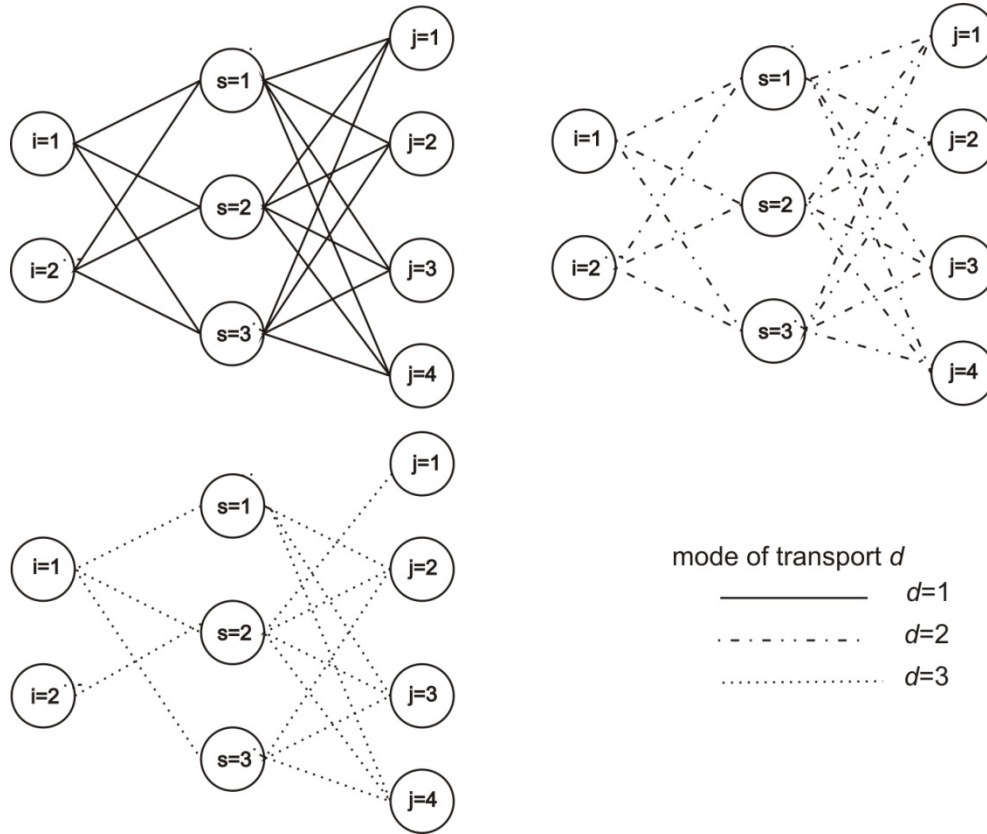
Figure 5. The all acceptable modes of transport among the participants in the supply chain
for the computational examples
(*source: own work*)

Table 3. The set of tables with numerical data for examples P1..P7
(*source: own work*)

s	F_s	P1, P5, P6, P7	P2	P3	P4
		V_s	V_s	V_s	V_s
1	1 200	1 500	1 300	1 600	2 200
2	1 500	1 500	1 300	1 600	2 200
3	1 000	1 500	1 300	1 600	2 200

d	Pt_d	Zt_d	P1, P2, P3, P4	P5	P6	P7
			Ct_d	Ct_d	Ct_d	Ct_d
1	60	10	10	10	10	10
2	180	10	60	30	60	120
3	600	10	240	100	200	400

j	k	Z_{jk}	Tc_{jk}	j	k	Z_{jk}	Tc_{jk}	j	k	Z_{jk}	Tc_{jk}	j	k	Z_{jk}	Tc_{jk}
1	1	10	10	2	1	10	10	3	1	10	10	4	1	10	10
1	2	10	10	2	2	0	10	3	2	20	10	4	2	0	10
1	3	5	10	2	3	10	10	3	3	0	10	4	3	10	10
1	4	10	10	2	4	10	10	3	4	20	10	4	4	0	10
1	5	5	20	2	5	5	20	3	5	0	20	4	5	15	20

i	k	C_{ik}	W_{ik}	i	k	C_{ik}	W_{ik}		j	P_j
1	1	100	100	2	1	150	100		1	10
1	2	200	100	2	2	210	100		2	15
1	3	200	100	2	3	150	100		3	15
1	4	300	100	2	4	250	100		4	10
1	5	300	100	2	5	350	100		5	20

s	k	R_{sk}	Tp_{sk}	s	k	R_{sk}	Tp_{sk}	s	k	R_{sk}	Tp_{sk}
1	1	1	2	2	1	1	1	3	1	0	0
1	2	1	2	2	2	1	1	3	2	1	3
1	3	1	2	2	3	1	1	3	3	1	3
1	4	1	2	2	4	1	1	3	4	1	3
1	5	1	2	2	5	1	1	3	5	1	3

i	s	d	A_{isd}	$R1_{isd}$	Tf_{isd}	i	s	d	A_{isd}	$R1_{isd}$	Tf_{isd}
1	1	1	10	1	1	2	1	1	5	1	4
1	1	2	20	1	3	2	1	2	10	1	6
1	1	3	40	1	4	2	1	3	20	0	7
1	2	1	12	1	1	2	2	1	10	1	4
1	2	2	24	1	2	2	2	2	20	1	6
1	2	3	42	1	3	2	2	3	40	1	7
1	3	1	5	1	1	2	3	1	15	1	4
1	3	2	10	1	2	2	3	2	25	1	6
1	3	3	25	1	3	2	3	3	35	0	7

s	j	d	G_{isd}	$R2_{isd}$	Tm_{isd}	s	j	d	G_{isd}	$R2_{isd}$	Tm_{isd}
1	1	1	2	1	1	2	1	1	4	1	1
1	1	2	4	1	1	2	1	2	8	1	1
1	1	3	10	0	2	2	1	3	16	1	2
1	2	1	2	1	1	2	2	1	3	1	1
1	2	2	5	1	1	2	2	2	6	1	1
1	2	3	12	1	2	2	2	3	15	1	2
1	3	1	14	1	1	2	3	1	5	1	1
1	3	2	12	1	1	2	3	2	10	1	1
1	3	3	20	1	2	2	3	3	15	1	2
1	4	1	15	1	1	2	4	1	2	1	1
1	4	2	13	1	1	2	4	2	4	1	1
1	4	3	30	1	2	2	4	3	10	1	2
3	1	1	2	1	1	3	3	1	6	1	1
3	1	2	4	1	1	3	3	2	10	1	1
3	1	3	11	0	2	3	3	3	20	1	2
3	2	1	3	1	1	3	4	1	4	1	1
3	2	2	6	1	1	3	4	2	8	1	1
3	2	3	14	1	2	3	4	3	20	1	2

i	s	k	d	K1$_{iskd}$	i	s	k	d	K1$_{iskd}$	i	s	k	d	K1$_{iskd}$
1	1	1	1	3	1	2	1	1	4	1	3	1	1	3
1	1	1	2	2	1	2	1	2	2	1	3	1	2	2
1	1	1	3	1	1	2	1	3	1	1	3	1	3	1
1	1	2	1	3	1	2	2	1	4	1	3	2	1	3
1	1	2	2	2	1	2	2	2	2	1	3	2	2	2
1	1	2	3	1	1	2	2	3	1	1	3	2	3	1
1	1	3	1	3	1	2	3	1	4	1	3	3	1	3
1	1	3	2	2	1	2	3	2	2	1	3	3	2	2
1	1	3	3	1	1	2	3	3	1	1	3	3	3	1
1	1	4	1	3	1	2	4	1	4	1	3	4	1	3
1	1	4	2	2	1	2	4	2	2	1	3	4	2	2
1	1	4	3	1	1	2	4	3	1	1	3	4	3	1
1	1	5	1	3	1	2	5	1	4	1	3	5	1	3
1	1	5	2	2	1	2	5	2	2	1	3	5	2	2
1	1	5	3	1	1	2	5	3	1	1	3	5	3	1
2	1	1	1	4	1	2	1	1	3	1	3	1	1	4
2	1	1	2	2	2	2	1	2	2	2	3	1	2	2
2	1	1	3	1	2	2	1	3	1	2	3	1	3	1
2	1	2	1	4	2	2	2	1	3	2	3	2	1	4
2	1	2	2	2	2	2	2	2	2	2	3	2	2	2
2	1	2	3	1	2	2	2	3	1	2	3	2	3	1
2	1	3	1	4	2	2	3	1	3	2	3	3	1	4
2	1	3	2	2	2	2	3	2	2	2	3	3	2	2
2	1	3	3	1	2	2	3	3	1	2	3	3	3	1
2	1	4	1	4	2	2	4	1	3	2	3	4	1	4
2	1	4	2	2	2	2	4	2	2	2	3	4	2	2
2	1	4	3	1	2	2	4	3	1	2	3	4	3	1
2	1	5	1	4	2	2	5	1	3	2	3	5	1	4
2	1	5	2	2	2	2	5	2	2	2	3	5	2	2
2	1	5	3	1	2	2	5	3	1	2	3	5	3	1

s	j	k	d	K2$_{iskd}$	s	j	k	d	K2$_{iskd}$	s	j	k	d	K1$_{iskd}$
1	1	1	1	3	1	2	1	1	3	1	3	1	1	3
1	1	1	2	2	1	2	1	2	2	1	3	1	2	2
1	1	1	3	1	1	2	1	3	1	1	3	1	3	1
1	1	2	1	3	1	2	2	1	3	1	3	2	1	3
1	1	2	2	2	1	2	2	2	2	1	3	2	2	2
1	1	2	3	1	1	2	2	3	1	1	3	2	3	1
1	1	3	1	3	1	2	3	1	3	1	3	3	1	3
1	1	3	2	2	1	2	3	2	2	1	3	3	2	2
1	1	3	3	1	1	2	3	3	1	1	3	3	3	1
1	1	4	1	3	1	2	4	1	3	1	3	4	1	3
1	1	4	2	2	1	2	4	2	2	1	3	4	2	2
1	1	4	3	1	1	2	4	3	1	1	3	4	3	1
1	1	5	1	3	1	2	5	1	3	1	3	5	1	3
1	1	5	2	2	1	2	5	2	2	1	3	5	2	2
1	1	5	3	1	1	2	5	3	1	1	3	5	3	1
1	4	1	1	3	2	1	1	1	3	2	2	1	1	3
1	4	1	2	2	2	1	1	2	2	2	2	1	2	2
1	4	1	3	1	2	1	1	3	1	2	2	1	3	1
1	4	2	1	3	2	1	2	1	3	2	2	2	1	3
1	4	2	2	2	2	1	2	2	2	2	2	2	2	2
1	4	2	3	1	2	1	2	3	1	2	2	2	3	1
1	4	3	1	3	2	1	3	1	3	2	2	3	1	3
1	4	3	2	2	2	1	3	2	2	2	2	3	2	2

s	j	k	d	$K2_{iskd}$	s	j	k	d	$K2_{iskd}$	s	j	k	d	$K2_{iskd}$
1	4	3	3	1	2	1	3	3	1	2	2	3	3	1
1	4	4	1	3	2	1	4	1	3	2	2	4	1	3
1	4	4	2	2	2	1	4	2	2	2	2	4	2	2
1	4	4	3	1	2	1	4	3	1	2	2	4	3	1
1	4	5	1	3	2	1	5	1	3	2	2	5	1	3
1	4	5	2	2	2	1	5	2	2	2	2	5	2	2
1	4	5	3	1	2	1	5	3	1	2	2	5	3	1
2	3	1	1	3	2	4	1	1	3	3	1	1	1	3
2	3	1	2	2	2	4	1	2	2	3	1	1	2	2
2	3	1	3	1	2	4	1	3	1	3	1	1	3	1
2	3	2	1	3	2	4	2	1	3	3	1	2	1	3
2	3	2	2	2	2	4	2	2	2	3	1	2	2	2
2	3	2	3	1	2	4	2	3	1	3	1	2	3	1
2	3	3	1	3	2	4	3	1	3	3	1	3	1	3
2	3	3	2	2	2	4	3	2	2	3	1	3	2	2
2	3	3	3	1	2	4	3	3	1	3	1	3	3	1
2	3	4	1	3	2	4	4	1	3	3	1	4	1	3
2	3	4	2	2	2	4	4	2	2	3	1	4	2	2
2	3	4	3	1	2	4	4	3	1	3	1	4	3	1
2	3	5	1	3	2	4	5	1	3	3	1	5	1	3
2	3	5	2	2	2	4	5	2	2	3	1	5	2	2
2	3	5	3	1	2	4	5	3	1	3	1	5	3	1
3	2	1	1	3	3	3	1	1	3	3	4	1	1	3
3	2	1	2	2	3	3	1	2	2	3	4	1	2	2
3	2	1	3	1	3	3	1	3	1	3	4	1	3	1
3	2	2	1	3	3	3	2	1	3	3	4	2	1	3
3	2	2	2	2	3	3	2	2	2	3	4	2	2	2
3	2	2	3	1	3	3	2	3	1	3	4	2	3	1
3	2	3	1	3	3	3	3	1	3	3	4	3	1	3
3	2	3	2	2	3	3	3	2	2	3	4	3	2	2
3	2	3	3	1	3	3	3	3	1	3	4	3	3	1
3	2	4	1	3	3	3	4	1	3	3	4	4	1	3
3	2	4	2	2	3	3	4	2	2	3	4	4	2	2
3	2	4	3	1	3	3	4	3	1	3	4	4	3	1
3	2	5	1	3	3	3	5	1	3	3	4	5	1	3
3	2	5	2	2	3	3	5	2	2	3	4	5	2	2
3	2	5	3	1	3	3	5	3	1	3	4	5	3	1

Table 4. The set of tables with results (decision variables: X_{iskd}, Xb_{isk}, Y_{sjkd}, Yb_{sjk}, Wx_{ik}, Vx_s, Dx_d)
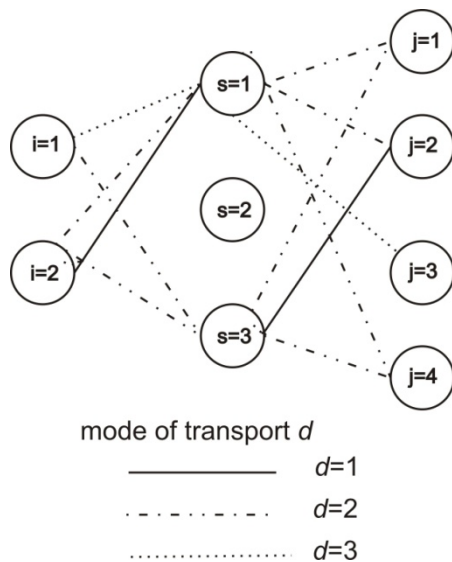for example P1 ($Fc^{opt} = 37820$)
(*source: own work*)

i	s	k	d	X_{iskd}	i	s	d	Xb_{isk}
1	1	1	3	40.00	1	1	3	1
1	1	2	3	23.00				
1	1	5	3	16.00				
1	3	2	2	7.00	1	3	2	1
1	3	5	2	9.00				
2	1	3	1	1.00	2	1	1	1
2	1	4	1	6.00				
2	1	3	2	12.00	2	1	2	1
2	1	4	2	18.00				
2	3	3	2	12.00	2	3	2	1
2	3	4	2	16.00				

s	j	k	d	Y_{sjkd}	s	j	d	Yb_{sjk}
1	1	1	2	10.00				
1	1	2	2	3.00	1	1	2	1
1	1	5	2	2.00				
1	2	1	2	10.00				
1	2	3	2	10.00	1	2	2	1
1	2	4	2	4.00				
1	2	5	2	5.00				
1	3	1	3	10.00				
1	3	2	3	20.00	1	3	3	1
1	3	4	3	20.00				
1	4	1	2	10.00				
1	4	3	2	3.00	1	4	2	1
1	4	5	2	9.00				
3	1	2	2	7.00				
3	1	3	2	5.00	3	1	2	1
3	1	4	2	10.00				
3	1	5	2	3.00				
3	2	4	1	6.00	3	2	1	1
3	4	3	2	7.00	3	4	2	1
3	4	5	2	6.00				

s	Vx_s
1	1500
2	0
3	625

i	k	Wx_{ik}
1	1	40
1	2	30
1	5	25
2	3	25
2	4	40

d	Dx_d
1	2
2	8
3	2

Figure 6. Left-hand side: a network of multi-modal optimal solution (Fc^{opt} = 37820) for P1.
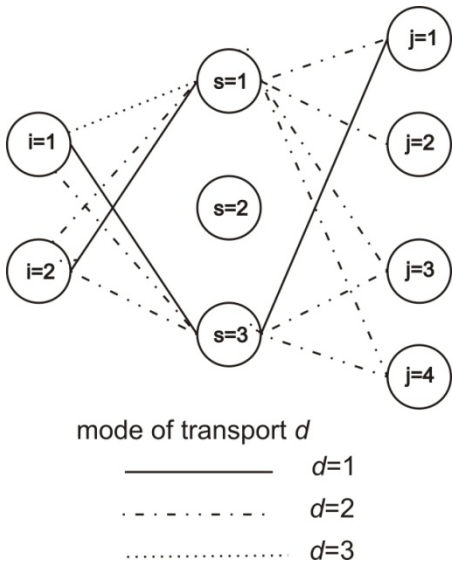Right-hand side: a screen shot of an optimal solution for P1.
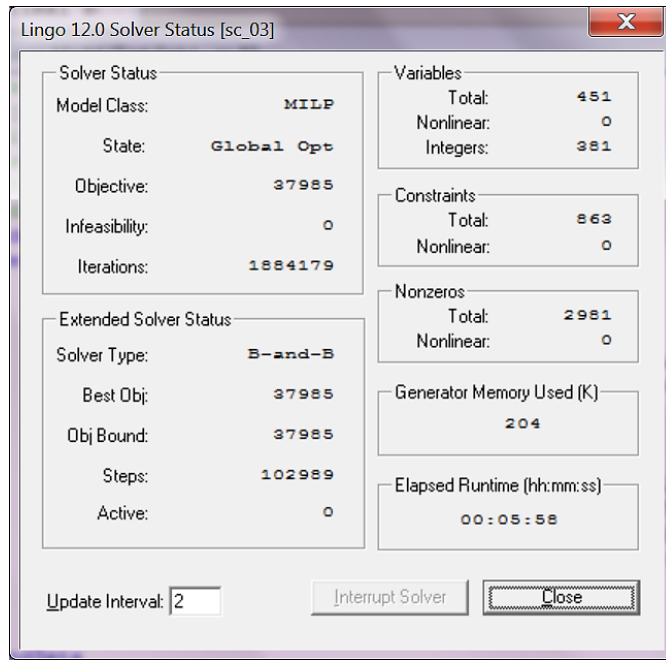
Figure 7. Left-hand side: a network of multi-modal optimal solution (Fc^{opt} = 379850) for P2.
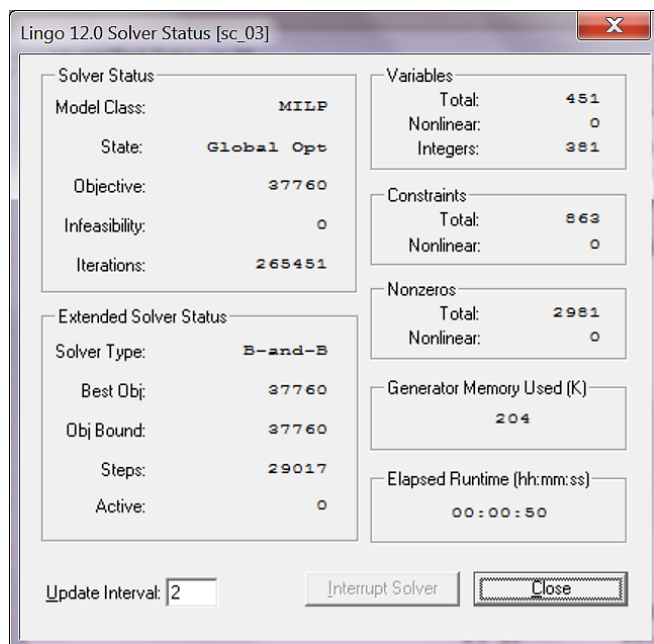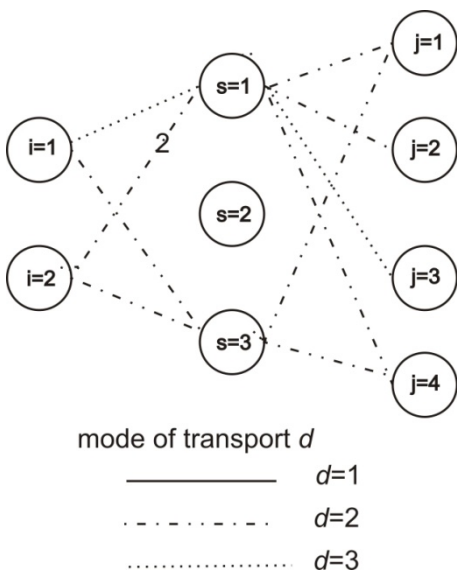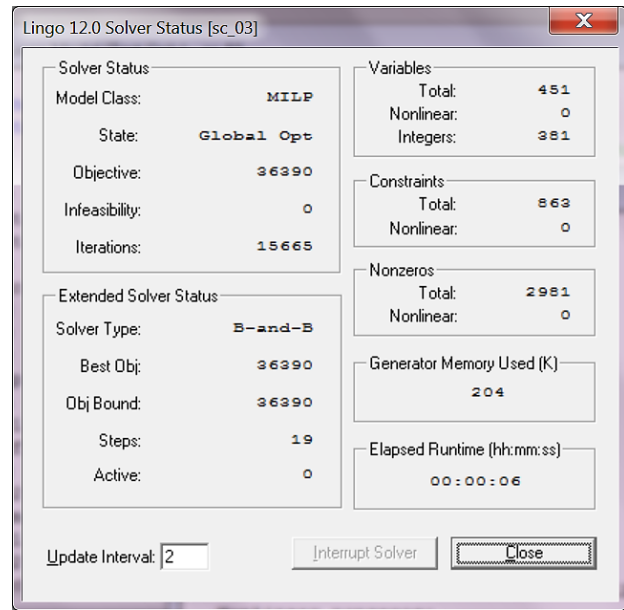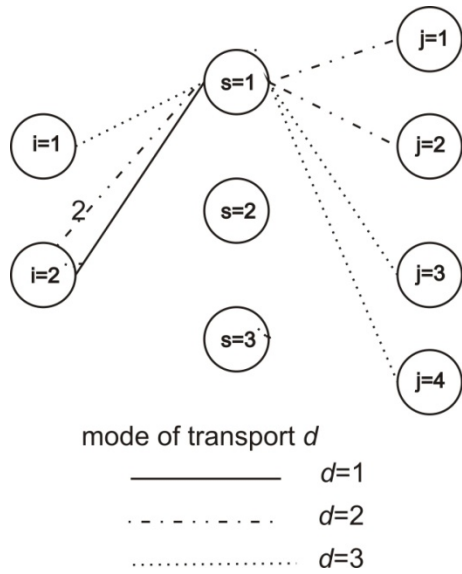Right-hand side: a screen shot of an optimal solution for P2

Figure 8. Left-hand side: a network of multi-modal optimal solution (Fc^{opt} = 37760) for P3.
Right-hand side: a screen shot of an optimal solution for P3

Figure 9. Left-hand side: a network of multi-modal optimal solution (Fc^{opt} = 36390) for P4.
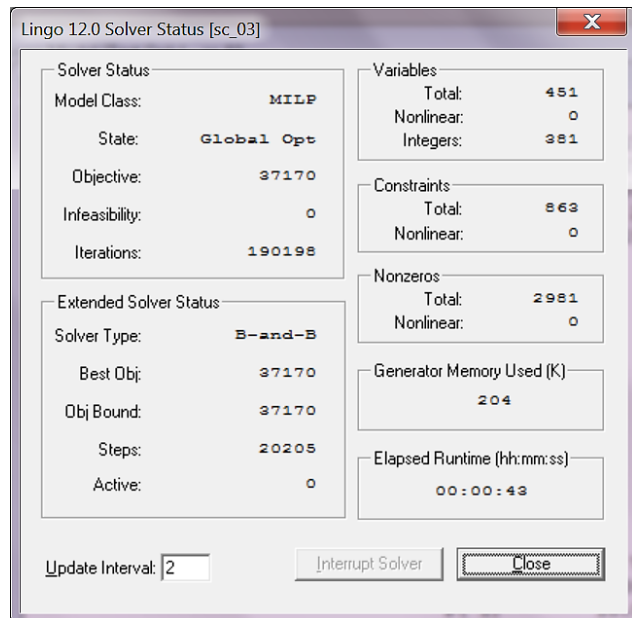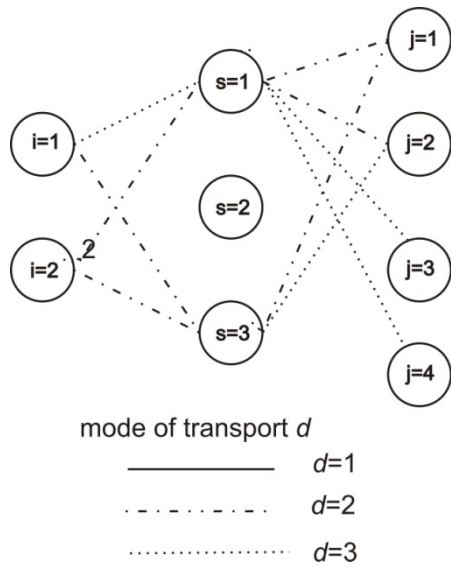Right-hand side: a screen shot of an optimal solution for P4

Figure 10. Left-hand side: a network of multi-modal optimal solution (Fc^{opt} = 37170) for P5.
Right-hand side: a screen shot of an optimal solution for P5

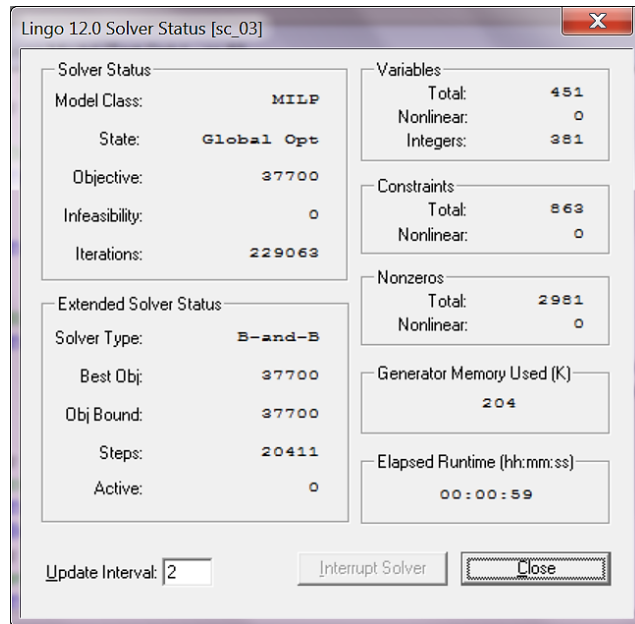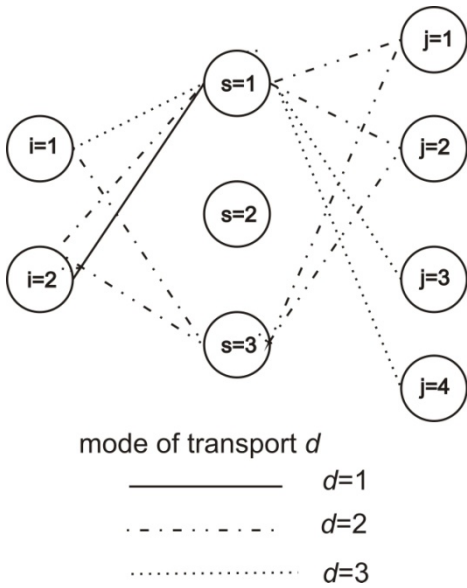Figure11. Left-hand side: a network of multi-modal optimal solution (Fc^{opt} = 37700) for P6.
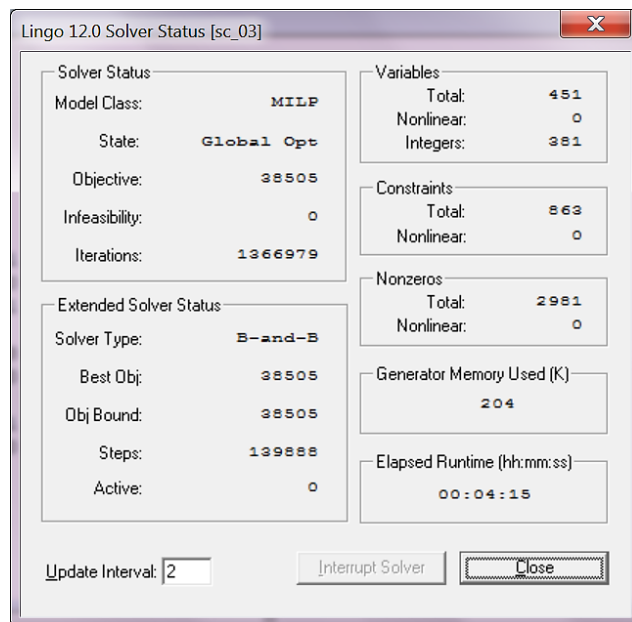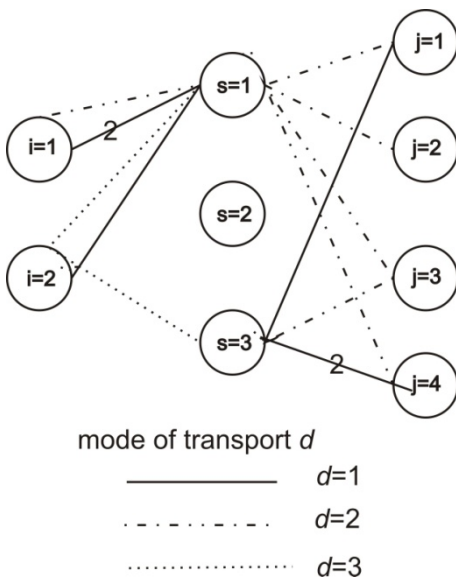Right-hand side: a screen shot of an optimal solution for P6

Figure12. Left-hand side: a network of multi-modal optimal solution (Fc^{opt} = 38505) for P7.
Right-hand side: a screen shot of an optimal solution for P7

To estimate the influence of parameters on the solution, additional experiments were carried out (much more than P1 .. P7). The effect of selected parameter (V_s) on the solution is presented on chart (see Fig. 13). For these studies assumed that the values of other pa-rameters are the same as for example P1. As shown in the diagram (see Fig. 13) the value of the parameter V affects almost linearly the value of the objective function.
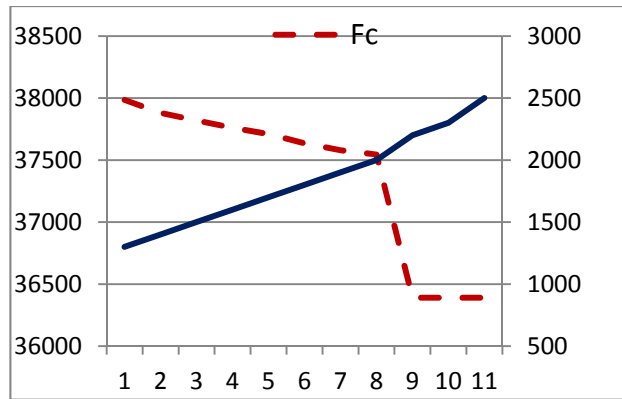
Figure 13. The impact of parameter V for the solution-stabilization
of the solution despite the increase V

That is, the larger the value of V, the smaller the value of the objective function. This happens until the volume reaches a value of about 2100. Above this value, the objective function does not change and has a minimum value. Additionally, you can determine the use of only one distributor to deliver supplies as confirmed by P4.

8 Conclusions

The paper presents a model for optimizing supply chain costs. Creating the model in the form of a MILP problem undoubtedly facilitates its solution using mathematical programming tools available in LINGO package[1], in CPLEX[2] or others. The model should be implemented in one, selected environment package. Implementation of the model in the LINGO package and the computational experiments was presented. The approach from the perspective of optimizing logistics provider that has access to all data and all participants in the downstream chain is very interesting.

After the implementation of the language from the LINGO mathematical modeling package, a number of computational experiments were conducted. Seven of them in the form of examples P1 .. P7 were described in the article. Based on the experimental results, analysis and previous experience, the authors can state that the proposed model and its implementation ensure a very large range of applications. First, they allow finding the distribution flows (decision variables) for the modeled supply chain in optimal or feasible

multi-modal network, which minimize the global cost satisfying the needs of customers. Second, they offer a lot of possibilities for decision support in supply chain management through the solutions sensitivity analysis and determination of the range and quality of the effect of various parameters on the cost and even on the structure of the supply chain. The analysis presented in the article, only in terms of the capacity available to distributors and producers fully confirms this statement.

On the one hand, a number of computational experiments show the correctness of the proposed model, on the other hand, they indicate high volumes of calculations that resulted from the nature of the model. This in practice may result in obtaining feasible solutions. Therefore, further work on the presented model and on other models of decision making in the field of supply chain management, manufacturing, etc. will be conducted in two environments. In the first environment we will focus on finding feasible solutions using CLP (Constraint Logic Programming) [23]. The other environment will employ LINGO-type packages for finding the optimal solution based on the results from the first environment. It can be concluded that it would also be multi-modal approach to the implementation and modeling.

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HUMAN PERFORMANCE IMPROVEMENT IN THE HEALTH CARE ORGANIZATIONS. RESULTS OF EMPIRICAL STUDY IN POLAND

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Abstract: Human Performance Improvement (HPI) as well as human aspects in Quality Management (QM) has received strong attention from researches. Many studies investigate the level of health care services and their main determinants. This paper seeks the relationships between the concepts of HPI and QM. The aims are to present the HPI practices on the example of EFQM Business Excellence Model criteria. HPI criteria were measured by EFQM model in Health Care Organizations (HCO) in Poland with use of case study methodology conducted on the basis of self-assessment reports documentation. The study included all HCO which are Polish Quality Award winners in the years 2005-2010. Studied HCO belonged to public sector. Results of study: (1) showed that the rules of HPI apply to all criteria of the EFQM model in Human Resources Management range, (2) justified the role and importance of HPI in the evaluation QM in HCO. The use of the EFQM model to assessment of the quality level of HCO is helpful for implementation of aimed improvement. Building QM awareness contributes to HCO creation of the need for management mechanisms and the development of medical service personnel function which is related to HPI.

Key words: Human Performance Improvement (HPI), Quality Management (QM), EFQM Business Excellence Model.

1   Introduction

Implementation of quality principles in health care organizations (HCO) as well as their improvement is necessary for the growth of patient satisfaction. A number of studies have suggested that "approximately 30% to 40% of the patients do not receive necessary care according to current scientific evidence and 20% to 25% of care provided has been medically unnecessary and potential harmful" [2, p. 4]. Improvement should be understood as an action intended to achieve excellent state, which is expressed in the organization's objectives. In this context, the importance of assume Quality Management (QM) has the principles defined by the European Foundation for Quality Management (EFQM), which include: [16, p. 26]:

- achieving balanced results,
- adding value for customers,
- leading with vision, inspiration and integrity,
- managing by process,
- succeeding through people,
- nurturing creativity and innovation,
- building partnership,
- responsibility for a sustainable future.

With regard to human resources management (HRM), these principles are the basis of high - performance work system (HPWS), which is oriented to achieve better reliability, safety and performance. HPWS is define as "integrated set work practices result in that engaged employees and positive individual, unit, or organizational level outcomes" [4, p. 38]. The structure of HPWS has evolved from QM and HRM theory and is related to Human Performance Improvement (HPI), which is mostly defined as "a systematic approach to identification, pointing at and implementation of solutions eliminating the barriers which make the execution of work difficult and which are done in a way that is effective so characterized by a positive (desirable) result (…). The rules of HPI concept are: orientation on the results of activities, concentration of work effects, system approach" [17, pp. 194-195]. The use of HPI concepts in management practice requires a change in thinking about people and their work. On the other hand, is subject to the store of knowledge about the impact of the effects of workers on the results achieved by the organization.

Table 1. Factors of quality in health services
(*source: own research based on [15, p. 57]*)

Author of study	Main factors	ServQual factors for HCO
Bjorkmann T., Hansson L., Sevensson B., Berglund I.	conversations with physician	• physical dimension the external and internal appearance of hospital (aesthetics, cleanliness), appearance of personnel (medical support), and equipment to medical equipment, the media in communicating with patients, facilities for patients (elevators, ramps, automatic doors)
	confidence in the physician	
	mutual respect	
	listening skills	
	information on treatment	
	medical care	• reliability the ability to implement appropriate services in accordance with ethical and medical standards, ensuring the personal safety of the patient and its properties during service
	the sensitivity of physician	
	medical advice if the patient's concerns	
	information on alternative treatments	
Pytle R.S., Mokwa M.P.	the interest of the patient	• reaction to the expectations of the patient the assistance offered to patients and their caregivers, the speed of action and responsiveness to the expectations of the patient, showing concern for the welfare of the patient
	hearing the patient	
	providing information	
	spending adequate time	
	warm, cordial welcome	
	individualized approach	• professionalism and trust kindness and the ability of staff to create a climate of trust and confidence, respect and affection for the patient when performing services
	friendly staff attitude	
	flexibility of staff	
	interior surgery	
	easy access	• empathy an individual approach to patient care for the mental comfort of the patient, understanding of the patient needs and expectations, paying attention to each patient, appropriate communication with patients
Zifko-Balia G.M., Krampf R.F.	professional competence	
	respect the patient's beliefs	
	interpersonal communication	
	the image of the hospital	
	adherence to ethical standards by medical personnel	

A synthetic measure might be their customer satisfaction index, calculated on the basis of research results, mostly surveys. „A new generation of patient satisfaction studies investigates how patients combine their attribute reactions to arrive their overall satisfaction" [11, p.117]. The factors influencing patients' perceptions of quality health services are presented in Table 1. Most of the presented factors refer to the relation physician-patient. In minority are factors relating to the relationship nursing care-patient and environment-patient. This set might rank the factors affecting patient satisfaction with medical services. The systematic measurement allows determining the level of excellence of health care services. Therefore constitutes the value provided to patients. The application of HPI model into HRM practice "helps in the achievement of improvement aims by identifying the fields which require improvement and the design of effective and efficient improving activities" [7, p. 14]. The concept of improvement requires parameterization of activities in the field of HRM. It makes it necessary to use a structure of qualitative and quantitative measurers in all the elements of personnel subsystem of a company. The relationships between elements of HPWS with rules of HPI and QM are presented in Table 2.

Table 2. HPWS, HPI and QM rules
(*source: own research based on: [4, pp. 40-41]*)

Authors of the study	Names of HPWS* practices	HPI**rules	QM*** rules/ HPI rules
West et al. (2002)	centralization	results of activities	• achieving balanced results, • leading with vision, inspiration and integrity, • responsibility for sustainable future / (results of activities)
	performance appraisal	system approach	
	sophistication of training	concentration of work effects	
	teamwork		
	training needs		
	training policy		
Boselie et al. (2003)	employee training	concentration of work effects	
	participation in seminars		
	skill development		
	direct supervision		
	teamwork		
	employee influence	system approach	• adding value for customers, • managing by processes, • building partnership / (system approach)
	employee participation		
	quality control		
	reward system		
Harmon et al. (2003) Scotti et al. (2007, 2009)	alignment	concentration of work effects	
	information		
	teamwork		
	trust		
	creativity		
	development	system approach	
	involvement		
	empowerment		
	performance – based rewards		
	performance enablers	results of activities	
Preus (2003)	employee scientific knowledge	concentration of work effects	• succeeding through people, • nurturing creativity and innova-tion / (concentration of work effects)
	employee experience – based knowledge		
	employee involvement		
	work design for low – skilled workers	system approach	
	work design for high – skilled workers		
	process templates		
Rondeau and Wagar (2006)	employee suggestion system	concentration of work effects	
	quality improvement teams		
	self – managing teams		
	employee attitude surveys		
	flexible work hours		
	job enrichment/job enlargement		
	self – scheduling		
	shared governance	system approach	
	incentive – based/merit pay		
	employee recognition system		

* HPWS: High – Performance Work System
** HPI – Human Performance Improvement
*** QM – Quality Management

As the table shows all HPWS practices are strongly associated with the HPI rules, which relate directly to the principles of QM. It should also be noted that most of HPWS practices is associated with the function of training in HRM and work organization. According to the criterion of level management, analyzed practices relate to a greater degree of operational management in HRM (e.g. control, budgeting, control effectiveness and efficiency of training). To include the strategic HRM practices, they related to personnel policy and strategy (e.g. training policy, empowerment). Through relationships with QM, principles HPI can be the basis for determining personnel strategies to improve the resulting actions. The analysis confirms that HPWS „aligns with other aspects of the organization, such as strategy (…), systems view of an organization (…). Valuable practices should be viewed as best practices and that more practices should be linked with positive outcomes" [4, p. 44]. This represents cohesion of QM with HPI. To answer the question, which of the practices are commonly used by HCO for assurance high quality services and achievement high patient satisfaction make possible the assessment of achievements in the HPI. One possibility is self-assessment according to criteria of EFQM Business Excellence Model, which is based on the principles of QM.

2 Business Excellence Model for health care organizations

Models of excellence are used to assess the level of excellence in QM including the aspect of HRM. It is worth noting, that there is observed a certain kind of unwillingness in public sector to implement EFQM Model of Excellence. Preferred model is CAF-Common Assessment Framework, specific and adapted for public organizations, including public HCO. It is based on the premise that excellent results in organizational performance, citizens/customers, people and society are achieved through leadership driving strategy and planning, people, partnerships and resources and processes. It looks at the organization from different points of view at the same time and represents the holistic approach of organization performance analysis. The CAF model consists of 9 criteria and 28 sub-criteria. Each criterion of the CAF model is assessed by considering a number of sub-criteria on the basis of specific scoring system.

The overall structure of the model CAF forms two groups of criteria:

- enablers (including leadership, policy and strategy, people, partnership and resources, processes),
- results (including customer results, people results, society results, key performance results).

CAF model in the perspective of HPI refers mainly to the following criteria: leadership, employees, business performance in its relations to the publics - clients (patients) and in relations with employees. This allows study the level of excellence in the organization from the external and internal perspective. As it was mentioned earlier, the basic tool of Business Excellence Model (BEM) is the self-assessment. Organizations should demonstrate the evidences of the fulfillment of the criteria. They can be synthetic descriptions of practices and numerical data (indicators, statistics), showing their implementation and results (effects). They are the basis for carrying out the scoring level of excellence. It can be assumed that achievements of winners of BEM might be a kind of benchmark parameter. „Benchmarking between organizations is often practiced through the use of performance indicators, which are defined as measurable aspects of care which give an indication of quality, safety, efficiency and accessibility" [3, p. 24]. Best practices also allow determine the directions and areas of quality services improvement in HCO.

The most popular business excellence scheme in Poland is Polish Quality Award (PQA). It was established in the 1995 by following organizations: the Quality Committee of the National Chamber of Commerce, the Polish Research and Certification Centre and the Foundation "Teraz Polska". As every national quality award in Europe, it is based on the EFQM model of excellence. The prize of PQA is dedicated to all Polish companies that, through the implementation of QM philosophy, have achieved an increase of customer satisfaction, employees and business performance. Model CAF covered by PQA has the same structure of criteria as the CAF model covered by EFQM. From 1995 to 2010 PQA winners were 60 enterprises. In the great majority (63%) were the winners of manufacturing and service companies (public organizations were 34%, and only 3% educational).

Table 3. Description of the category and leadership practices
(*source*: *own study*)

HPI rules	Criterion CAF	Health care organizations (HCO) – winners of PQA
	Leadership	Number of practices
system approach	development, prevalence vision and mission	• 1 respondent has correctly identified the vision and mission • 3 respondents have identified the mission, however haven't identified the vision • 1 respondent has identified the vision however hasn't identified the mission
	translating the vision and strategic objectives into operational objectives and actions	• 4 respondents have not defined objectives • 1 respondent has stated the specific objectives (Balanced Score Card)
	enabling stakeholders in the process of setting goals and develop strategies	• 3 respondents have not described how they contribute to the development strategy • 2 respondents did not provide data
	creating a network of relationship and partnership	• 3 respondents have co-organized preventive programs, • 1 respondent has signed cooperation agreements with other national hospitals • 1 respondent has signed cooperation agreements with foreign hospitals
concentration of work effects	contribute to the development organization's management system	• all of respondents are characterized by the formal leadership and commitment
	communicating vision and strategy at all levels of the organization	• 2 respondents used direct formal communication • 3 respondents did not provide data
	encourage and support activities related to learning and use the results of these activities in the management	• 1 respondent was engaged in organizing scientific conferences on management and health economics • 2 respondents participated in seminars on medical issues • 3 respondents did not take action
	stimulating and encouraging the transfer of entitlements	• 2 respondents have delegated responsibilities, authority and responsibility (job descriptions) • 1 respondent had self-designated rules for decision-making by employees • 2 respondents had no delegated entitlements
	financing activities in the field of learning and improvement	• 4 respondents have fixed the budget • 1 respondent has no budget fixed (ongoing financing of all activities)
	helping employees to achieve their plans and to achieve objectives	• 1 respondent used flexible working hours policy, provided financial support (post-graduate studies, medical specialties)
	understanding and responding to needs of employees	• 2 respondents held regular meetings with management • 3 respondents conducted meetings with heads of hospital departments divisions (unknown frequency) • all respondents did not provide results of the meeting (the findings or decisions)
results of activities	recognition of individual and team efforts	• all respondents had no formal rules-the immediate superior decides
	implementation of systems of rewards and incentives	• 1 respondent had motivational system • 3 respondents had applied bonus rules

3   Methods

The study included all HCO[1] (N = 5) which are PQA winners in the years 2005-2010. Studied HCO belonged to the public sector. Evaluation of their level of excellence has been carried out with the following criteria of CAF model: leadership, employees, business performance in relations with employees and customers - the citizens (patients). The study was conducted on the basis of competition documentation - HCO's self–assessment reports. The analysis includes only those criteria of CAF model, which have been described in the self-assessment model and directly related to HRM. The following hypotheses are examined:

Hypothesis 1: Effective leadership determines the use of quality management principles in HRM.

Hypothesis 2: HRM practices enable the realization of the principles of HPI.

Hypothesis 3: Results achieved by HCO in relations with employees are essential of activities for the HPI.

Hypothesis 4: Based on the measurements indicators showing better reliability, safety and performance in HCO.

4   Findings

4.1   Leadership

The leadership criterion should provide evidence of how leaders:

- trace out the directions of the organization through the mission, vision and values,
- develop and implement a system for managing the organization, its actions and change,
- motivate and support people in the organization and inspire them by example.

As studies have shown starting with a project dominant approach and transitioning to a strategy or cultural approach produces the greatest continuous quality improvement outputs [1, pp. 283-293]. In CAF model, there are 14 specific criteria, which in the category of leadership allow assess the foundations of continuous quality improvement outputs. List of 13 practices identified in the HCO in the category of leadership with the HPI rules is shown in Table 3.

As is apparent from the practice the HPI is strongly associated with the category of leadership. In the studied HCO, leadership is largely a formality, which is not sufficient to improve the quality of health care services. By analyzing the orientation of the leaders HCO on the concentration of work effects can be said that only 50% has its base. This is insufficient because „approach, in which leaders empower frontline clinical providers to assist in development of important care processes, should increase not only quality of patient care and work quality but patient safety as well. Managers need to pay attention to how organizational policies and practices are perceived among front line care providers" [14, p. 342]. Important role of the leaders is also implementing knowledge–building practices as the creation of new knowledge resources.

In the studied HCO, there was no common practice of leaders in this field. Only a small group of leaders participated in seminars and symposia on medical issues. The study showed no evidence of dissemination of knowledge among employees. There were no conditions for a system approach in most of the HCO. No basis (mission, vision) reduces the formation of an effective strategy. Its absence prevents the use of coherent control and evaluates the effectiveness of workers, work design and a systematic approach to the empowerment of employees. As the results of research an empowered work force will create greater outcome gains than the effects of specific team process improvement alone [1, pp. 283-293]. No strategy also makes it difficult to create relationships and partner network, which surveyed HCO practices are limited mainly to prevention programs for local communities. Most respondents of HCO cited that there was no motivation system and the system of recognition of individual and team achievements. Therefore cannot be measured the achievement of results of activities in HRM. There is also a lack of advisory bodies in the organizational structure of the HCO's. The necessity of their existence is confirmed by results of studies, which show that „hospital boards to improve their oversight of quality of care and patient safety, including taking such actions as establishing a board quality committee and developing strategic goals, specific to quality performance" [5, p. 146]. It must be stated that there were no in surveyed HCO:

- established guidelines for leadership to enhance mutual trust and respect in relations with employees,

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[1] Classification of hospitals in Poland is different from Europe, therefore assumed name HCO.

- electronic communication, which limits the effectiveness of forms of communication (vertical, horizontal),
- activities to promote an organizational culture focused on the example of welfare of patient, teamwork, respect,
- studies of the impact of leadership on the internal (e.g., processes, personnel, ethics) and external (patient satisfaction, image, market share of medical services) environment.

In none of the cases, there was no application of the quality program for health care services associated with the strategy. The research found that "effective leadership has been shown to enhance health care quality programs and likewise, quality management initiatives are reported to have positive impact on patient safety and other health care organizational outcomes" [6, p. 130]. It can be concluded that quality improvement in leadership category outputs indicates the low level of leadership and applying the principles of QM and HPI. Therefore, the first hypothesis was confirmed.

4.2. People

Strategy and personnel policy is the basis for implementation of activities aimed at HPI. The possibility of achieving the strategic objectives also depends on HPWS, which should be supported by proper implementation of personnel functions (e.g., motivating, rewarding, and training). Not without significance is the concern for the environment because "hospital work environment not only influences staff variables such as satisfaction and turnover but also influences the ability to provide high quality and safe care to patients" [14, p. 334]. In criterion "People" must be demonstrated evidence of how the organization:

- plans, manages and develops human resources strategy and planning,
- defines, develops and uses the skills of employees by adjusting the individual and organizational objectives,
- involves employees by development of dialogue and empowerment.

The CAF model has the 10 specific criteria, which in the category of people allow the assessment of continuous quality improvement foundations outputs.

The statement of eight practices identified in the HCO in this category with the HPI rules is presented in the Table 4.

The table shows that the majority (75%) of the data refers to the concentration effects of work in the HPI. There are no data confirming the relationship with the principle - results of activities. Most respondents did not have HRM policies. The lack of this specific document identified in the form of personnel policy has also been described in the results of other studies related to HCO in Poland. They "did not confirm the existence of such a document in any of them in Podlaskie voivodeship (…). More than 28% of respondents were convinced that the personnel strategy in the form of a document does not exist, 14% had no opinion and 58% was sure that it did not exist in their institution" [8, pp. 73-74]. All investigated HCO declare that their managers have informed employees about principles of HRM, however there is no evidence for the communication of information to employees. Conditions of employment and salaries are generally not flexible. Therefore it can be stated that the surveyed HCO may not have sufficient system approach to quality improvement in people category outputs. The participation of workers in identifying goals does not occur in 80% of HCO's. The management imposes goals. Since the share of workers in the task forces is not voluntary (100% of responses), the achievement of group objectives by employees is limited. This is a negative phenomenon, because „physicians involvement on clinical process improvement teams early in the program is essential for continuous quality improvement success" [1, pp. 283-293].

No HCO does not analyze training needs in order to ensure adequate competence of employees and does not plan the structure of human resources. However, 80% surveyed HCO created training plans based on staff reports, with only 20% that have developed training regulations. Implementation of training plans and training to enable workers to gain professional experience declare 5 HCO, but there are no numerical data confirming the plan and concerning other forms of education and work experience (post-graduate studies and job placement). This prevents the assessment of the foundations satisfying the health needs of patients. There is also formalized information considering the training. In 2 HCO employees can obtain information only in the HR office.

Table 4. Description of practice in the category – people
(*source: own study*)

HPI rules	Criterion CAF	Health care organizations (HCO) – winners of PQA
	People	Number of practices
system approach	develop and prevalence policies and principles of HRM	• 2 respondents identified the personnel policy • 3 respondents had no formal personnel policy
	introduce the flexibility in salaries and employment conditions	• 2 respondents introduced contracts as a form of employment • 2 respondents identified specific criteria for granting a bonus for employee performance (no reference to the teams) • 1 respondent had not undertaken any solutions
concentration of work effects	encourage employees to evaluate managers	• 3 respondents carried out once a year a formal evaluation (questionnaire survey) • 2 respondents had no results of the assessment
	develop and implement a policy to ensure equal treatment of all groups and individuals	• all respondents declared in the rules of work lack any form of employment discrimination • 3 respondents investigated the dynamics of the employment of disabled persons and foreign nationalities
	create and communicate the principles of training	• 4 respondents had no formal training plans • 1 respondent had only the regulations of training
	implement the training plans and training to enable employees and work experience	• all respondents declared the implementation
	provide workers with information about training opportunities	• 1 respondent published the guides of training • 2 respondents informed about training (available in HR) • 1 respondent published information on an internal website • 2 respondents informed about training in meetings with heads of hospital departments divisions
	set the objectives together with the employees and review the implementation of tasks	• 1 respondent set with workers operational objectives and reviewed the tasks on the basis of indicators during the regular meetings
	promote team work, create task forces	• all respondents appointed by a decision of management task forces - workers' participation is not voluntary

Similar are conclusions of results of other studies in the Polish HCO - „20% of respondents pointed at the lack of system approach to trainings which in their opinion were only occasional and organized at random" [7, pp. 73-74]. A positive phenomenon is the conducting by three HCO formal assessment of the management carried out by employees and that all examined HCO declare no discrimination in employment.

Generally can be concluded that in the analyzed criterion there is a low quality improvement in health care services outputs. HRM practices of HCO significantly limit the implementation of the principles of HPI. The results of research did not confirm the hypothesis 2.

4.3 Results of the activities in relations with the employees

Results of the HPI activities in the internal dimension refer to organizational performance achieved in relations with employees. They can be measured by the level of satisfaction (overall index), degree of employee involvement, performance evaluations of employees, fluctuations and level of sickness absence (specific indicators). Achievements of the organization relating to the results of measurements of satisfaction and motivation of employees and other measurements of relationships with employees should be obtained by the self–assessment evaluation of this criterion.

Table 5. Description of practice in the category results of the activities in relations with the employees
(*source*: *own research*)

HPI rules	Criterion CAF	Health care organizations (HCO) – winners of PQA
	Results of the activities in relations with the employees	Number of practices
system approach	employees' opinions about the: • creation and realization of values, mission, vision, policy and strategy; • communication, delegation of powers, equal opportunities, express recognition, involvement; • the satisfaction in the fields: the conditions of employment , facilities and services, health and safety conditions of work, job security-salaries and additional benefits, colleagues relations, change management	• 1 respondent systematically investigates in surveys for the employees (60% of respondents positively evaluate) • 1 respondent conducts a study and stopped its continuation • 3 respondents do not provide the investigation
concentration of work effects	participation in training and the usefulness training evaluation results	• all reported number of people are trained, of which 1 respondent reported the number of groups (professional: doctors, nurses and administration staff) • nobody does not assess the usefulness of training
	the results of analysis of evaluation and review staff	• 1 respondent leads analysis of work • 1 respondent carries out an assessment of the employee and his direct supervisor respondents do not conduct the assessment and review of employees
	the level of absence and incidence, trends in employment and staff rotation statistics	• 3 respondents carry out an evaluation, of which 2 perform the analysis in time

The CAF model has six specific criteria, which can assess the continuous quality improvement outputs. The statement of four practices identified in the HCO in this category is presented in Table 5.

The table shows that majority of the data (75%) refers to the concentration of work effects. No HCO provided data on employee participation in the systems proposals to improve quality of care services. Do not are counted the indicators of employee participation in internal consultations and meetings of working groups, although all of the HCO declared to promote teamwork by creating task forces. This undermines the credibility of the answers given by the HCO. There is no employee involvement in matters of the company. There are no data on the number of employs involved in the initiatives (ideas, request, and enhancements). The interest in the opinions of managers of employees is low. Only one HCO carries out regular surveys of employees, of which 60% of the evaluation are positive. No assessment of the usefulness of training in all surveyed HCO indicates that the development of knowledge and skills to improve the quality level of health care services is neither managed nor controlled. Only one HCO conducts analysis of work (work efficiency, assessment skills, personality traits and behaviors), so assessment of the HPI is not a common practice. The study did not confirm hypothesis 3. Generally, it can be concluded, that quality improvement in health care services outputs in the analyzed criterion of HCO in the perspective of results in the relationship with employees is very low.

4.4 Results of the activities in the relationship with customers - citizens (patients)

External evaluation activities oriented on HPI are results of patient satisfaction survey. It can be assumed that the high results of internal evaluation of HPI determine high results of external evaluation. Patient satisfaction evaluation plays an important role in quality of health care services.

Table 6. Description of practice in the category results of the activities in relations with customers - citizens (patients)
(*source: own research*)

HPI rules	Criterion CAF	Health care organizations (HCO) – winners of PQA
	Results of the activities in relations with patients	Number of practices
concentration of work effects	the actions undertaken to make changes	• 4 respondents carry out patient satisfaction survey • 3 respondents describe the activities carried out on the basis of the results • 1 of the respondents leads continuously comparing the value of the index patient satisfaction (general and by divisions in the hospital) • 1 of the surveyed uses different questionnaires for different groups of patients (patients: in hospital divisions, specialist clinics, diagnostic services)
system approach	activities undertaken for building customer loyalty and empower of customer-citizen	• 4 respondents do not inform patients of their rights • 1 respondent publishes a document "Rights and obligations of the patient"
results of activities	improving the quality and accessibility of information published	• 5 respondents do not ask in the questionnaires for patients for the information on quality of services • 3 respondents availability has quantified
	improving accessibility	• 1 respondent extends the work time • 5 respondents does not examine the medical services run-time
	improving support and advice to the customer-citizen and procedures treatment of complaints	• 5 respondents have Patients' Rights Ombudsman • 2 respondents examines value of the complaints of patients indicator over time and analyzes complaints • 1 of the respondents reports court cases filed by patients

"Thus, the measurement of hospitals service quality has to be based on perceived quality rather than objective quality. It is because service quality is intangible, heterogeneous and its consumption and production occur in tandem" [13, p. 478]. In the self-assessment should be described the achievement of the organization relating to the results of measurements of satisfaction of citizens-clients (patients) and other measurements of the relationship with them. In the CAF model there are 5 specific criteria, which allow assess the foundations of continuous improvement quality outputs. All the practices identified in the HCO with the HPI rules are presented in Table 6.

As the table shows all the practices refer to the principles of HPI. The vast majority of HCO conducts patient satisfaction surveys. The results of these studies in 80% are false, because:

• there are methodological faults in formulating of questions and answers scales,
• only 20% of the factors of quality in health care services (SERVQUAL) have been included in the questionnaire survey,

• there is a lack of comparative research of patients' opinions in relation with the opinion of others (physicians, medical staff-nurses, paramedics).

A positive phenomenon in the field of research is the diversity of patient satisfaction questionnaires, depending on the groups of patients (one HCO). Surveys conducted in most of the HCO are not permanent, so it is impossible to specify the parameters of quality of medical services most appreciated by patients. As the results of research, "the two dimensions most strongly positively associated with global satisfaction were receiving the expected medical help and being treated well by the doctor. To wait at the reception without getting information correlated negatively to patent satisfaction, and participation in the medical decision - making correlated positively" [12, p. 86]. In the HCO there is a lack of knowledge about the impact of service quality factors on a global satisfaction of patients. In all examined HCO communication with the patient is not designed, managed, and improved. The distribution of information leaflets is limited. Call center activity (three HCO) is reduced to provide information on hours

and days of receptions by physicians and to maintain records of the visit. Four respondents did not inform the patients of their rights. Only one HCO were observed as proactive in communication with patients. This is far from enough, because „recent research shows that online communities can be a critical venue for knowledge sparring and transfer and has the potential to deliver socio-emotional support to patients, promote more active patient involvement in disease management, facilitate patient education and improve patient self-efficacy, which in turn leads to positive outcomes" [9, p. 124]. Additional, patient "participation in online health communities: has involved raising found to support research on specific diseases, sharing of innovate ideas to improve health care services, contributing to the development and the diffusion of public policies in health care" [10, p. 345]. Generally can be concluded, that all surveyed HCO have not created foundation for development of quality assessment and improvement activities in health care services. The study did not confirm the hypothesis 4, because of the lack of reliable foundations for measurement and analysis.

5 Conclusions

All investigated HCO have certified QM system according to ISO 9001:2009, so it was assuming that the HPI is an integral part of the management system. This is due to connection QM principles set out in ISO 9000:2006 with QM system requirements set in ISO 9001:2008. As showed the studies, HRM is characterized by a low level of excellence. Important weaknesses in the functions and personnel actions limit the efficacy and efficiency of personnel management. It can also be stated that the rules of QM are not included in none of HCO in the QM system. Therefore, improving the efficiency of workers is rather accidental and has a very limited scope. Such a situation in HRM in studied HCO demonstrates that practice of meeting the needs and expectations of patients is not implemented. This causes also no grounds for improvement. Patient satisfaction with medical services is not a parameter in the system management of HCO. This may result from lack of knowledge management, or fear of the results of satisfaction surveys. Negative assessment carried out by patients could:

- force a change, and then induce the willingness and commitment to their implementation,

- challenge existing attitudes of doctors and medical staff to patients,
- verify the self–assessment of physicians and medical staff and hospital executives,
- reveal previously hidden problems (personal, organizational, managerial).

Generally, it should be pointed that the studied HCO have not fulfilled sufficient conditions to obtain the desired effects, directly or indirectly associated with the concept of HPI. Low level of medical services quality requires preparation and implementation of radical changes, which should start with improving the leadership effectiveness.

6 Research implications

The first research implication relates to the impact of QM on health care outcomes. Identification and characterization of the factors influencing change and improvement outputs can provide arguments for the implementation of the principles of quality in the HCO. Future research could provide a description of mechanisms for achieving the desired effect of improvement in care services outputs. The specificity of medical services requires the implementation of methods and tools used in QM, which can help analyze and evaluate the effectiveness and efficiency of activities.

The second research implication relates to the role of human factors in improving the quality of medical services and increasing efficiency. Appropriate practices HRM is the basis of HPI. Demonstrating the strength of his correlation by studies will allow the changes in management system of HCO. Impact of changes on the value of the index patient satisfaction should be measured. The results of research in this area will help determine the scale of the target values for these indicators.

The third research implication relates to the processes that affect desired quality assurance level in medical services. Identification of processes with their direct or indirect links affects patient satisfaction and is necessary to create a systematic approach in QM of medical services and implement both the principles of QM and HPI. The conclusions of the analysis process (internal, external) and the values of indicators can be the basis for conducting the benchmarking, as a part of continuous improvement.

7 Practice implications

From a practical perspective, applications of improvement principles of QM into health care organization have influence on quality services level. In the practice "to see continuous quality improvement impact after the first year or two requires measuring specific areas where continuous quality improvement activities have been completed rather than looking at overall performance (…), hospitals using an analyzer (following an established sequence of steps) or prospector (more innovate in new program development) implementation approaches would experience a greater degree of continuous quality improvement implementation than those using other approaches" [1, p. 291]. However, the basis for quality improvement is the knowledge about activities and their results in internal and external relations. Therefore, the use of the EFQM model to assessment of the quality level of HCO is helpful for the implementation of changes aimed at improvement. Building awareness of quality management contributes to HCO creation of the need for management and the development of medical service personnel function. The results of studies presented might become an inspiration to carry out self-evaluation and exploration of sources to improve the quality of medical services.

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HOLDING GROUPS: A SAFE CORPORATE STRUCTURE AT THE TIME OF RECESSION

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Abstract: This article makes a case for holding groups as a type of enterprise structure which guarantees capital and structural security at the time of economic and political transition in the 1990s, which in a way prepared them for the global recession in the early 21st century. The case study of PKN Orlen is presented to illustrate the typical economic developments which accompanied privatisation and commercialisation of Polish state-owned enterprises. A major part of the article addresses management mechanisms which make a holding structure immune to strong economic turbulence which would otherwise be destructive to individual daughter companies.

Keywords: holding groups, holding company, holding structure, technical and business aspects of building holding groups, impact of the holding group structure, strategic characteristics of holdings.

1 Introduction

The current recession forces businesses to search for safe new corporate structures. One such structure which was successfully applied during Poland's transition and EU access is the holding group.

State-owned enterprises were forced to restructure as the country was adopting the market economy. There were three phases of that process. First, companies had to break free from the government's control and learn the rules of market economy with the primary forces of supply and demand and successful performance driven by effective marketing departments analysing the marketplace and manufacturing well aligned with the demand for products and services. This called for a change in the organisational structures and day-to-day operations. Hence, companies were massively restructured and privatised.

The second phase was that of business development and specialisation. Businesses became dependent on market growth and learned to diversify and identify new markets.

In the third phase, companies felt the consolidation pressure as Poland was getting ready for EU membership. Mergers and acquisitions became commonplace. Capital groups were formed to gain more competitive advantage in global markets.

The main benefits of business restructuring included[1]:

- improved timeliness of operational decisions at the level of subsidiaries,
- holding company management not expected to make day-to-date management decisions,
- increased motivation of management teams of subsidiary companies to generate profit and improved accountability,
- improved ability to measure the performance of subsidiaries.

Holding companies manage on a selective basis focusing on certain aspects and areas of the group's activity that are deemed to be critical[2].

The following sections of the article present:

- the history of the PKN Orlen group since the establishment of the Polish Petroleum Monopoly (Polski Monopol Naftowy),
- mechanisms of managing a holding group as a structure of capital links where the goals and prerogatives of a holding group must be skilfully transposed to the goals and prerogatives of individual subsidiaries in the group,
- technical and economic aspects of the formation of holding groups in the context of political and economic transition of Poland and Central and Eastern Europe,
- the impacts of a holding company on the business of group companies in terms of their research and development, production, procurement and sales;

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- key functions of the holding company with respect to managing operations, group development and effective share holding structure,

- strategic qualities of holding structures when used as economic restructuring tools with decentralised management functions of the entire holding group and its individual member companies.

2   Case study: PKN Orlen

The history of the company begins in July 1944 with the establishment of an organisation responsible for securing the petroleum infrastructure that had survived WWII and the Nazi occupation and for restoring the distribution system. The first government decree establishing the Polish Petroleum Monopoly (*Polski Monopol Naftowy*) was issued on August 14, 1944. However, the name was changed in October of the same year into State Bureau for Petroleum Products Sales (*Państwowe Biuro Sprzedaży Produktów Naftowych*)[3]. Central Office of Petroleum Products (*Centrala Produktów Naftowych*) was established in December 1945. The organisation was again renamed ten years afterwards into "CPN" Central Management for Trade in Petroleum Products (*Centralny Zarząd Obrotu Produktami Naftowymi "CPN"*). The previous name was restored plus its acronym was added three years later *Centrala Produktów Naftowych "CPN"*. In December 1995, CPN was restructured into a joint-stock company wholly owned by the State Treasury, which was reflected in the "S.A." (*Spółka Akcyjna*) added to its name. At the end of its life, the company owned a network of more than 1400 petrol stations and a fleet of over 600 tanker trucks for transporting fuels.

The political change which began in the 1980s in Poland gave rise to the adoption of market economy in the country. On July 1, 1993, *Mazowieckie Zakłady Rafineryjne i Petrochemiczne (MZRiP)* (Masovian Refinery and Petrochemical Works), which had been established on December 1, 1959, was transformed into a joint-stock company called Petrochemia Płock S.A. In May 1998, the Council of Ministers (the Government) took a decision to form a national petroleum corporation by merging Centrala Produktów Naftowych CPN S.A. and Petrochemia Płock S.A. Polski Koncern Naftowy S.A. was formally established

on December 7, 1999 as a petroleum processing and oil derivatives distribution group of companies.

The group includes oil refineries in Poland (Płock, Trzebinia, Jedlicze), three in the Czech Republic and one in Lithuania (Mażeikiai). Orlen signed an agreement with the National Assets Fund of the Czech Republic in June 2004 whereby it became a majority shareholder (63%) of the Czech Unipetrol a.s. group of companies in the oil processing and fuel distribution sector. The Company operated a network of 338 premium and economy petrol stations as at year end 2011. The number of Benzina Plus premium stations offering a broad selection of non-fuel products and services increased from 113 to 115 in 2011. There were 223 sites in the economy sector.

As at year end 2011, ORLEN Deutschland operated a network of 567 petrol stations, of which 541 under the STAR brand in the economy sector, 25 stations adjacent to hypermarkets and on premium site.

The group now includes the following companies: ORLEN Księgowość (shared accounting services centre), Basell ORLEN Polyolefins (plastics and synthetic materials), ORLEN (petrol station brand in the Polish and German market), UniPetrol (Czech refinery group), Benzina (petrol station brand on the Czech market), Solino (manufacturing of industrial brine and underground storage of oil and oil derivatives), Anwil (a chemical company in Poland), ORLEN KolTrans (rail transport and haulage), ORLEN Lietuva (a refinery in Lithuania), ORLEN Transport (transport of petroleum products), ORLEN Lietuva (a petrol station brand on the Lithuanian market), ORLEN Oil (oil supplier), ORLEN Gaz (gas producer), SHIP SERVICE (marine fuels), Bliska (a petrol station brand on the Polish market), Star (a petrol station brand on the German market), Benzina Plus (an economy petrol station brand on the Czech market), Ventus (an economy petrol station brand on the Lithuanian market), Rafineria Trzebinia (refinery in Trzebinia, Poland), Rafineria Jedlicze (Refinery in Jedlicze, Poland), ORLEN Ochrona (security company), ORLEN Prewencja (ocupational health and safety services, fire prevention services and environmental services) merged with ORLEN Eko, ORLEN Petrocentrum (a brand on the Polish market), ORLEN Laboratorium, ORLEN Asfalt (asphalt producer), ORLEN Automatyka (industrial automatic control systems), ORLEN Administracja (services), ORLEN Wir (rotating machines), ORLEN Medica (medical services), ORLEN Budonaft (petrol

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[3] http://www.orlen.pl/PL/OFirmie/Nasza%20historia/Strony/Historiaslowami.aspx

station construction), Spolana (chemical company in the Czech Republic), ORLEN International Exploration and Production Company (international oil exploration and development), ORLEN Upstream (domestic oil exploration and development).

ORLEN's retail business relies on efficient logistics network including overground and underground storage and long-distance pipelines. The group holds a licence for onshore and offshore oil and gas exploration across Poland and one of its priorities is unconventional gas exploration. A panel of experts from subsidiaries ORLEN Upstream Sp. z o.o. and ORLEN International Exploration and Production Company BV reviews an average of 80 exploratory projects a year in Central Europe, Africa, Middle East, North America and the Caspian Sea Basin.

The history of PKN Orlen is the best proof of the efficiency of the holding group structure. With its diversified business profile, the group can generate revenues from a number of different sources and it has grown to become one of the leaders and largest corporations in the oil industry in Central and Eastern Europe.

3 A holding group: group management mechanisms

Unlike in capital groups where member organisations may be related to each other based on contracts, agreements or equity links, mutual relations between organisations in a holding group are based on equity links[4].

The structure of a holding group derives from equity linkages. An organisation may play a superior role in the group if it holds stock in other subsidiaries in the group or a subordinate role if its stock is owned by another company. A holding group consists of:

- a holding company (controlling entity),
- one or more subsidiary companies (controlled entities).

The holding company is also referred to as the mother company and subsidiaries as daughter companies. The holding company has the following powers:

- it holds a controlling stock,
- it controls and supervises subsidiaries,

- it has the voting right in the bodies of its subsidiaries.

The rights of subsidiaries are defined in the holding agreement. Holding agreements concluded with each subsidiary define:

- the share of the holding company in the subsidiary's assets,
- the right to exercise permanent control over the subsidiary's management, business and legal affairs,
- the persistency of the holding relationship (the acquisition of shares is of a definitive nature),
- additional provisions (future collaboration, position etc.).

The holding structure is complex and clearly defined group objectives must be adequately transposed into the objectives of each of the subsidiaries. Thus, the nature of a holding is the control over the business of other companies through equity exposure. The goal of such control is to:

- shorten the decision-making paths,
- manage certain areas of business on a shared basis for all the companies with the group,
- reduce overhead expenditures,
- improve the efficiency of innovation cycles,
- ensure consolidated financial reporting.

The powers of each group member must be clearly defined and they will depend on the functions of each subsidiary in the group. Holdings are complex structures. Jung lists the following prerogatives of the holding company:

- engage in business activity on its own account and risk,
- accumulate and redistribute part of the profit generated by subsidiaries,
- exercise control over the business and financial performance of companies through managing their balance sheets and profit and loss accounts,
- address issues related to international and domestic distribution and ensure adequate service infrastructure (to maximise efficiency),
- initiate and develop business development and modernisation programs jointly with individual subsidiaries to improve the efficiency of revenue generation by engaging in financing and creation of new companies,

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[4] *Holding group – a group of enterprises where one of the them is superior over the others*. Leksykon zarządzania (ed. M. Adamska), Difin, Warsaw 2000, p. 161.

- analyse and initiate the adoption of management and information systems in subsidiaries to improve efficiency and productivity,

- conduct or outsource research and analyses using international or Polish consultancies,

- represent the holding company in supervisory boards of subsidiaries,

- define the role of the holding company in appointments to top management positions in subsidiaries.

The holding company is thus empowered to operate in the following dimensions:

- strategic planning,

- operational control,

- management control.

Strategic planning is vital in a holding structure. It allows the holding company to decide on the key objectives of the entire organisation and define ways of implementing them. The objectives are defined as financial targets to be achieved and/or maintained (equity growth rate) and as positioning targets (position within the group).

Operational control lies within the units of the holding company and applies to individual task and transactions. It may also lie within subsidiary companies.

Finally, management control is exercised in order to supervise and effectiveness and efficiency of strategy implementation with the main focus on the efficiency of program delivery and centres of accountability, i.e.:

- cost centres managed by administration, legal and accounting departments with respect to planned (predictable) cost such as inputs, labour and unplanned cost (revenue centres at the discretion of management),

- profit centres (subsidiary companies),

- investment centres.

The efficient operation of a holding group depends on the quality of information handled internally and externally to support the best possible planning and decision-making in the interest of the organisation. Economic analyses conducted by the organisation are a crucial source of information which feeds into business development and investment policies of a holding group.

The holding group is a structure which improves the efficiency of equity management and allows the group to venture into higher risk business opera-

tions. Holding companies can:

- ensure transitional funding where one subsidiary may support others within the group,

- avoid limitations related to antitrust legislation,

- spread investment risks,

- create new businesses (companies) at a lower risk for external investors.

Both new companies aspiring to gain a significant market position and large corporations which cannot be efficiently managed because of its size may find forming a holding group a viable business proposition. Decision-making becomes decentralised in a holding group. Moreover, a holding group:

- creates an opportunity to effectively use the equity of one entity to support another in consideration of a share in its profits,

- introduces and mobilises free non-investment capital,

- may be used as a vehicle to obtain good terms on loans to support projects identified by the equity holder,

- has its own management and legal independence (may have) linked to a specific asset, civil and penal accountability,

- is an effective means of concentrating equity and economic decision-making (benefits from central policy, tax optimisation and capital flows between group members),

- enjoys additional benefits related to the construct of the holding company (a wholly-owned limited liability company), which legally separates "personal" and company assets.

However, there are some disadvantages to a holding structure. First, it has not existed in the economy long enough and its members often lack extensive experience too. There is no detailed legislation in place. Some of the negative aspects of holding structures are:

- lack of control over the linkages within the system: lack of full control in critical situations,

- low level of protection for shareholders in subsidiary companies: possible abuse of majority rights,

- limited communication between shareholders (the mother company is the only one to have access to all information: this allows manipulation between the companies,

- available option to form a wholly-owned partnership: this limits the rights of others,

- given their equity position, subsidiary companies are perceived as hostages of the mother company,
- with the personal links in place, such structures are examples of monopolistic practice.

The holding groups listed below had different origins. Some emerged out of the restructuring of foreign trade enterprises (*centrala handlu zagranicznego*), a special type of state-owned enterprises in the Eastern bloc allowed to engage in the exportation and importation of goods and services and settling in 'hard' currency, e.g. Agros. Other, such as Hortex or Stalowa Wola, resulted in the transformation of existing 'combines' or industrial conglomerates.

The newly formed holding groups have been confronted with the need to develop effective group management methodologies. The experience in recent years demonstrates that executives in a number of companies that operate as part of holding groups do not fully appreciate the specificity of such group structures, particularly in terms of management approach.

While there have been a number of successfully operating holding groups there is still a gap to be filled with respect to effective and efficient management. Implementing relevant management systems to ensure effective control over the company and its business is nothing else than developing and enforcing a set of internal documents that provide detailed descriptions of such management systems, define their scope and specify the roles and responsibilities of the company officers and executives. Having such management systems in place ensures management accountability.

A formal structure is critical for management systems to be properly anchored in the organisation. Both delegating tasks and responsibility should be formally regulated in the organisation. This helps eliminate the phenomenon of collective accountability and improves the efficiency of managing company resources.

4 Holding groups in manufacturing and food processing industries: technical and business aspects of building holding groups

Industrial holding groups are complex structures consisting of a number of diverse business organisations with different profiles (manufacturing different products, delivering different services etc.).

There are high-growth holding groups in the food processing and other industries in Poland. The following section presents holding groups in food processing, machine and plastics industry. These holding groups have evolved in a number of different ways.

Holding groups in food processing have emerged in one if two ways:

- the Agros Group came into being following the restructuring of a foreign trade enterprise,
- the Hortex Group is a result of a transformation of an industrial conglomerate into a limited liability company then converted into a holding company after privatisation.

The Agros Group is an example of a holding group resulting from the restructuring of a foreign trade enterprise[5]. The foreign trade enterprise had lost most of its markets in the late 1980s. Like other foreign trade enterprises under communism, Agros had its suppliers and customers and a specified (dedicated) assortment, in this case food products. The enterprise generally engaged in trading goods. In 1992, 70 per cent of the enterprise's revenue came from international trade. The main focus of its restructuring was vertical and some horizontal diversification. The business was broadened to include purchasing of produce, processing, storage and sales on the domestic and international markets. These changes helped the group restructure its revenue streams in 1995: trade accounted for less than 50 per cent, 33 per cent from processing and the remainder from distribution. The Agros Group became one of the largest producers of fruit and vegetable products. It has a captive distribution network and owns such well known brands as "Krakus" (fruit and vegetable products), "Fortuna" (juices), "Łowicz" (jams), "Ptyś" for carbonated drinks and many other. Agros owns several major food processing plants and it has recently expanded into the dairy and meat sector.

The Agros Group has a strong position with 25 per cent market share in the juice market, 20 per cent in concentrated juice, 70 per cent in vegetable juice, 50 per cent in jam and around 20 per cent in the apple squash market. The policy of vertical diversification pursued by the group (it is considering widening its "Krakus" and "Fortuna" portfolios) is continued and has recently been supplemented by horizontal expansion into dairy and meat products).

The Agros Group is one of the top ten companies listed on the Warsaw Stock Exchange in terms of capitalisa-

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[5] Romanowska M., Trocki M., Wawrzyniak B. (ed.) - *Grupy kapitałowe w Polsce.* Difin, Warsaw 2000, p. 213.

tion and is ranked 42 on the Financial Times list of leading businesses in Central and Eastern Europe.

Agros Holding S.A. is the equity and financing hub whose role is to make strategic decisions affecting the entire organisation and to manage the subsidiary companies. With centralised management of finance, organisation, marketing and production, the Management of Agros Holding S.A. pursues the strategy of seeking economies of scale and equity concentration benefits. It also seeks to enhance its marketing function by consolidating category and bran management.

The Agros Group is planning to acquire more businesses as they become available as privatised entities. It allocates a major budget to new acquisitions to strengthen its position in the domestic market and expand to international markets. It is planning to upgrade its distribution system and apply the latest sales techniques in major Polish cities. The goal of the Agros Group is to obtain ISO 9000 certification by implementing a quality assurance system and environmental projects. This will help the group enhance its position in international markets.

Holding groups in the machine industry have mainly resulted from restructuring processes as the heavy industry faced significant challenges during Poland's economic and political transition in the late 1980s. Companies in the steel, shipbuilding, defence, mining, heavy machinery and installations and construction industries suffered from the loss of their existing customer base in the East and other countries of the Eastern bloc where transition weakened the local economies. Polish enterprises experienced difficulties collecting their receivables for exported goods and services.

To save the endangered enterprises the government transformed them into holding groups. The main goal was ensure that the existing industrial conglomerates could successfully operate in the market economy.

The creation of a holding group helps companies improve their competitive position, leverage the experience of other group members and engage in joint projects, e.g. research and development in the area of new designs, technologies, manufacturing methods etc. More opportunities that come with more resources available to companies help companies in holding groups boost their performance.

According to M. Trocki, being part of a holding group allows companies to implement a series of fundamental functions:

- operational management,
- capital group development,
- share management.

Operational management reflects the technical benefit from the transformation of an enterprise into a holding group. The other two functions reflect the economic benefits.

5   Impact of the holding group structure on the business of subsidiaries

With regard to operations, a holding structure ensures better technical means for the entire group and individual subsidiaries. The barrier of constrained resources can be more easily overcome and resources become easier to manage. Operations include both the core business and ancillary activities. Here is the illustration of both types of operational activity in manufacturing. The following are the core business activities:

- research and development (often done by a shared R&D facility which could otherwise not be affordable to individual companies),
- procurement (joint procurement reduces cost and contribute a more rational use of resources and allows the group to help those subsidiary companies which face procurement challenges),
- production (joint production of goods, production collaboration and support),
- sales (joint sales policy implemented by a trading company or by specialised dealers or sales units or by external traders.

With regard to ancillary activities, the following can be done jointly by companies in a holding group:

- inputs management (joint management of inputs within the existing structure),
- transport management (a transport company can provide its services to other companies within the group),
- fixed asset and workshop management (this can be done a specialised company or plant within the group),
- energy (e.g. an electricity distribution company may exist within the group and serve other subsidiaries),
- quality control (a share quality department),

- environmental controls (the high cost of environmental performance it is critical to have a specialised environmental laboratory and environmental department in the group),
- general administration (shared administration of the entire group and its subsidiaries.

Being part of a holding group helps individual companies enhance their operations. The above operational management and group development management functions have a positive impact on business performance. All specific tasks performed within the operations management function must be considered as they contribute to the overall success of the holding group concept. Here is a list of such operational tasks:

- activity planning for the entire group and to some extent (different in different holding groups) for individual companies,
- organising activities - like in planning, it applies to the entire group and its subsidiaries; the aim is to achieve performance targets,
- investment projects implemented by the mother company using resources developed by the entire group (e.g. internal financing),
- personnel (human resources) management - effective use of highly specialised personnel,
- finance management - effective use of funds generated within the group,
- internal audit - a task performed by specialised personnel to identify irregularities which may hinder performance and to identify corrective actions,
- marketing - a dedicated department develops a strategy for the entire holding group and individual subsidiaries to ensure high profits,
- public relations for the entire holding group and all individual companies.

Individual business performance of subsidiaries in a holding group is vitally important as is market positioning. Therefore, groups need to focus on their business development function with such individual tasks as:

- setting goals and objectives (identify the business area, the competitive position and other growth-oriented parameters),
- develop a strategy for the group and strategic guidelines for subsidiaries (identify targets to measure performance against the strategy),

- engage in new types of business and exit existing businesses (non-portfolio); develop businesses which promise strong performance,
- organise the holding group - establish a structure to ensure effective management,
- distribute funds to support the activities of group members (this includes investment funds) to improve the economic performance of supported companies,
- define and manage human resources policies in companies (management) to influence and control their operations,
- attract strategic investors for subsidiaries,
- ensure recovery in companies facing major business challenges by injecting capital generated elsewhere in the group,
- manage the transfer of know-how (between companies in the group) to leverage the experience within the group,
- coordinate and centrally manage the key functions: R&D, finance, investments, implementation etc. They are extremely costly but indispensible for the group to maintain its market position,
- review the operations of subsidiaries in terms of their performance against strategic objectives (strategic controlling) to measure the level of economic success.

Share management is a function that seeks to achieve and economically viable distribution of shares in the group. The following are some of the specific tasks in this function:

- define the rules and objectives of share management (to be defined by the owner(s)),
- buy/sell shares (according to existing rules and guidelines),
- attract new investors to subsidiaries (to improve their competitive position and to ensure access to state-of-the-art design, technologies and manufacturing techniques),
- maintain shareholder relations to meet financial targets (define the rules of collaboration and control),
- define profit distribution policy (to reflect level of contribution made by each company in the group),

- review the financial performance of subsidiaries and ensure coordination of activities in this area (supervise for adequate utilisation of available resources),
- mobilise financial support for subsidiaries (mobilise free capital outside of bank financing and control),
- provide internal loans (using capital developed by group members),
- manage clearing and settlement of intra-group transactions and ensure their compliance,
- coordinate financial reporting of subsidiaries and report on a consolidated basis,
- provide financial advice to subsidiaries through specialised departments in the holding company.

6   Holding as a restructuring tool: strategic characteristics of holdings

The restructuring processes affect a variety of enterprises in Poland. A large group of restructured enterprises are former 'combines' or conglomerates. They had to be restructured according to carefully selected rules because of the size of their assets and the type of business. Out of many other available restructuring options, the holding group approach was adopted in cases such as Huta Stalowa Wola (steelworks) or Petrochemia Płocka (petroleum company). This approach allowed decentralisation and demonopolisation, and facilitated the adoption of an efficient structure which generates profit and warrants a significant market position.

A holding group-oriented restructuring allowed the creation of spin-offs which became separate entities with full accountability for their financial performance. This fuelled initiative and entrepreneurship as spin-off companies (subsidiaries) were delegated rights and responsibilities. The decentralisation of responsibilities lead to the enhancement of decision-making processes in the subsidiaries and a better distribution of risk from one enterprise into individual spin-offs depending on the type of their business.

The decentralisation process resulting from the transformation into a holding structure affected the following aspects:

- delegation of responsibilities and powers to subsidiaries,

- operations management at the level of subsidiaries, which supported their conversion into profit centres,
- higher prestige of the management of independent companies.

This contributed to improved efficiency and entrepreneurship and increased the motivation and commitment of staff who identified themselves with their organisation. The powers and responsibilities delegated to such independent entities made them easier to manage. The cost and benefit analysis became possible, which entailed a much more rational use of resources.

Holding structures operate in line with strategies. These strategies differ from those for individual enterprises. There are two strategic levels:

- individual strategy of a company which is part of a group,
- group strategy.

The group strategy is that of the mother (holding) company which manages daughter (subsidiary) companies to increase their value. This process is called corporate parenting. The group strategy concentrates on three fundamental areas (supporting value growth):

- portfolio management,
- core business competencies (companies),
- improved financial performance of individual companies.

Fig. 1 illustrates the links between the group (corporate) strategy and the strategies of individual subsidiaries in a holding group. The corporate strategy guides the individual strategies of group subsidiaries. Individual strategies reflect the general strategy and must not stand in conflict with it.

7   Conclusions

The high position and performance of the holding groups presented in this article provide the best case for the concept. Here are some detailed benefits related to holding group structures:

- financial - reduced overhead cost, accumulation and redistribution of profit generated by subsidiaries, availability of transitional cross-financing within the group,
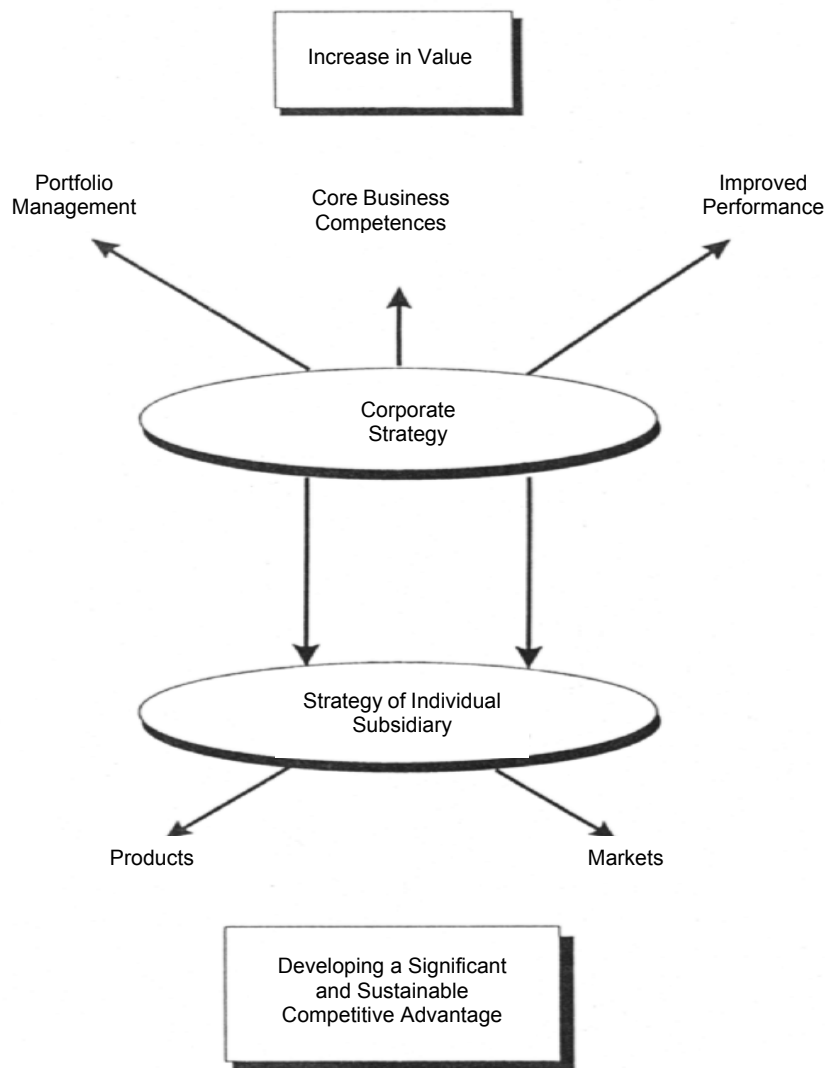
Fig. 1. Individual Strategies of Holding Group Members
(s*ource: [6, p. 31]*)

- organisational - organising forms or channels of domestic and international distribution, initiating and developing development and modernisation programs for subsidiaries, research and development, business analytics performed by specialised companies (Polish or international), organising procurement and ancillary functions (e.g. transport) and environmental controls,
- effective group functions in the area of operations management, group development management, and knowledge and human capital management,
- strategic features of a holding group as a tool of economic restructuring leading to decentralised management functions.

With the above-mentioned functions performed by the mother company, daughter companies can reduce their cost base and become more competitive in the domestic and international market.

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A TOTAL RISK ASSESSMENT IN AN ENTERPRISE

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Abstract: Risk assessment is an important task of risk management. It must take various aspects into consideration. For this reason the risk management involves various scientific disciplines: mathematics, psychology, law etc. Every institution must deal with many different kinds of risk. The question is: in order to ensure the continuation of the company, is it important to assess individual risk or to identify and evaluate the entire overall risk to the enterprise. This article aims to present a method of calculating the total organizational risk in relation to the ROI-return on investment (justifying the critical importance of profit [loss] in ensuring the continued operation of the entity).

Key words: risk, risk management, risk assessment, ERM, total risk, business continuity management.

1   Introduction

One of the crucial tasks of risk management is the assessment of identified risk. It should take various aspects into consideration. The quantitative, legal and psychological points of view are of practical importance in this case.

Thus, on the one hand, the quantitative risk measures should be analyzed critically, extensively described in theory and applied in practice. On the other hand, the issues arising due to accepting a risk must also be addressed. The answer to these issues implies the need for taking psychological factors into consideration.

"Risk analysis is a technical and systematic process to examine identified risks, isolate causes, determine the relationship to other risks, and express the impact in terms of probability and consequence of occurrence. Analysis begins with a detailed study of the risk issues that have been identified. The objective is to gather enough information about the risk issues to judge the probability of occurrence and cost, schedule, and technical consequences if the risk occurs" [7, p. 765].

Every institution must deal with many different kinds of risks. The question is: whether, to ensure the continuation of the company, it is important to assess individual risks, or to identify and evaluate the entire overall risk to the enterprise.

This article aims to present a method of calculating the total risk to organizations in relation to the planned return (justifying the critical importance of profit [loss] in ensuring the continued operation of the entity).

2   Risk and its assessment

For a start, we should ban the term measurement and say risk 'assessment'. Risks are about the future, an appreciation of potential difficulties or disasters. Measurements can only be about things that exist now or were recorded in the past. To jump to the future we need to make assumptions and to use models that are logical constructs build on these assumptions. Assumptions and models can never be validated in an absolute sense but they may be deemed acceptable in certain limited circumstances in order to support certain decisions.

Decisions that depend on risk descriptions are many. For example, on a short time scale, assuming markets behave normally, risk assessments should help make efficient use of resources, that is, achieve the most desirable risk/return trade-offs. Over the long term, managers as well as regulators are concerned about the viability of financial institutions. But a firm's survival depends not only on capital now but also on a host of other factors such as a good reputation, a viable franchise, an astute and cautious management, and a well-developed risk management function [9, p. 2].

Care should also be taken to capture information about the inherent risk. If this is not done the organisation will not know what its exposure will be if control should fail. Knowledge about the inherent risk also allows better consideration of whether there is over-control in place – if the inherent risk is within the risk appetite, resources may not need to be expended on controlling that risk.

This need to have knowledge about both inherent and residual risk means that the assessment of risk is a stage in the risk management process which cannot be separated from addressing risk; the extent to which the risk needs to be addressed is informed by the inherent risk whereas the adequacy of the means chosen to address the risk can only be considered when the residual risk has been assessed [18, p. 20].

Risk assessment assumes that the notion of risk is defined in a precise and measurable way. The concept of risk is understood as "the possibility of non-achievement of an explicitly formulated or implicitly arising objective of an enterprise" (cf. [2]). The possibility of non-achievement of a given objective results from uncertainty. It constitutes and is the very cause of risk. The definition clearly implies that an objective is always the point of reference to risk [16, p.12]. The objective describes the future condition that the enterprise is trying to achieve. Usually, the condition may be presented with the use of specific measuring values (indexes) such as e.g. profit, cost, turnover, the use of production capacities, market share. The objectives are often described in such a manner that at least (in the case of indexes where the highest possible value is striven for) or at the most the particular value should be achieved (in the case of indexes where the lowest possible value is desirable).

The non-achievement of objective means that the value is lower or alternatively that it has been exceeded. Such objectives are called level targets.

It occurs rarely that the value described by objective should be achieved precisely (point target).

Implementation of risk management in the enterprise has primarily two objectives:

- risk awareness among employees of the enterprise is increased,
- the appropriate methods are used to handle the specific risk.

Risk management deals with the pure and speculative risk. At the pure risk only pure loss is possible (material damages, financial losses, threats to life, ...). At the speculative risk besides the possibility of losses there is also a possibility of profit.

A simplified classification of risk is presented by P. Drucker, who identifies four types of risk. The first is a risk that a person must accept, such as driving a car to travel, or the use of tools that allow you to perform an action. The second type is a risk which a person can take and allow, which is taken, for instance, while skiing or doing a sport. The third is the opposite and is a risk that we cannot allow. It is incurred when success of a decision depends on luck, and the consequences can be tragic and irreversible, such as overtaking a car just before a hill. And finally, the fourth type - risks that we must take such as a desperate jump from a building on fire (cf. [11, pp. 13-14]). This interpretation made by the famous guru of modern management methods makes it entirely clear that risk is an essential element of life and it can be found in almost every area of human activity.

Making choices in situations of risk comes down to two important things: how attractive the consequences of the action are and how big the chances that we will reach the desired results are. This regularity was already noticed by Pascal, who pointed out that when taking a risk not only the consequences should be taken into account, but also the probability of their occurrence. He refers to natural phenomena, noting that many people feel excessive anxiety when they hear thunder lightning, although the incidence of death due to lightning is small (cf. [13, pp. 43-47]). Pascal comments on that with the following remark: „Fear of danger should be proportionate not only to the seriousness of danger, but also the probability with which this event can occur" (cf. [4, p. 58]).

While analyzing the risk of a project we can use two methods of quantification - formal and descriptive. Using a formalized method, the measured risk is quantitative. This approach includes the size and level of probability of risk occurrence, as well as a range of possible outcomes (in most cases it is a normal distribution), the expected timing of their occurrence and the expected frequency of risky events arising from a particular source, area or type of risk.

In the descriptive method, the measured risk is of a qualitative character, and the probability in this approach is described as high, medium or low. This approach, however, has a limited application, since such descriptions of probabilities are imprecise and ambiguous, and therefore they can be understood and interpreted differently by different people. Thus, in order to determine the level of probability accurately, we should use both, the qualitative and quantitative approaches (cf. [10, p. 46]).

Both in the literature and in practice it is universally agreed that in the case of quantitative risk assessment both the scale of possible losses and the probability of their occurrence should be taken into consideration[1]. This assessment needs to be done by evaluating both the likelihood of the risk being realized, and of the impact if the risk is realized. [18, p. 19]. Tyszka and Zaleśkiewicz claim, e.g., that the combination of the possible loss volume and its probability constitute a natural risk measure [12, p. 59].

In order to implement this method of assessment, the following questions must be answered:

- how to determine the size and probability of a loss?
- how to "combine" the size and probability of a loss in a reasonable way?

It is difficult to answer the first question, since there is often a lack of statistical data, which leads to the necessity of employing a subjective assessment. Such an assessment is influenced by cognitive factors. Jonen, Lingnau and Sagawe therefore suggested using the Analytic Hierarchy Process (AHP) as an instrument that could reduce negative effects of these factors and increase the transparency of assessment results [6].

The use of a risk matrix is described broadly in the literature on the subject as an adequate instrument allowing estimation of the size of risk (magnitude of losses, and their probabilities) using the quality parameters in the absence of sufficient quantitative data. Another advantage of this tool is that it can take into account the psychological characteristics of an individual decision maker, who estimates the likelihood and extent of losses. The information is filtered through the subjective „risk appetite".

Variance (alternatively a standard deviation) constitutes the qualitative risk measure which is most frequently applied both in theory and in practice.

Variance is regarded as an improper risk measure for two reasons

- variance does not measure deviations from a particular goal value, but from the anticipated value; as a rule, these two values are not identical,
- according to the variance formula, both the non-achievement and exceeding the goal value are regarded as a loss; this, however, only concerns the point targets.

The second point of criticism may be omitted in the case of level target, since a negative or alternatively positive semivariance can be used instead of the variance (cf. e.g. [14, p. 130]).

If in the semivariance formula the expected value is replaced with a given value of goal (a generalized semivariance) then the first point of criticism may be skipped as well.

As far as level targets are concerned, the generalized semivariance does not provide any satisfactory information on the risk volume. Namely, it only takes negative deviations from a given goal value (i.e. the loss) into account, not the positive deviations (i.e. profits), however. Zaleśkiewicz [15, p. 90] claims that 'according to the rules of decisive analysis, when assessing the risk volume, four parameters should be taken into consideration: (1) loss volume, (2) loss probability, (3) profit amount and (4) profit probability'. The comprehension of positive deviations is also of great significance from the point of view of legal assessment of risk. The legally acceptable risk should be distinguished from unlawful danger. Therefore, the relations between risk, costs and benefits need to be analyzed very carefully (cf. [16, p. 16]).

This is the reason why the risk rate is considered to be the most effective risk measure in the case of level targets. The risk rate is a quotient of average negative deviations from goal values and average positive deviations (cf. [2, p. 69]; [16, p. 52]). The lower the rate, the lower the risk.

3 Risk aggregation

Risk aggregation is a process to identify and illustrate the interaction of several, differently correlated individual risks of an organization in order to obtain the overall risk [17, p. 7].

Broadly, risk aggregation refers to efforts by firms to develop quantitative risk measures that incorporate multiple types or sources of risk. The most common approach is to estimate the amount of "economic capital" that a firm believes is necessary to absorb potential losses associated with each of the included risks. This is typically accomplished via mathematical or statistical techniques designed to assess the likelihood of potential adverse outcomes, although the use of specific stress scenarios is also relatively common [3, p. 1].

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[1] In single cases it is recommended to consider only the probability of loss as a risk measure (cf. e.g [14, p. 131]).

S.R. David ([5], p. 3) identifies the following six situations where some type of Risk Aggregation may be appropriate:

- Type 1: Aggregating Risks for a "Single Risk" where multiple outcomes are possible (e.g. fire – consequence can range from no harm to multiple fatalities, with each outcome having a different likelihood),
- Type 2: Aggregating Risks to an individual or group of people from a range of possible Accidents or Activities or Systems,
- Type 3: Aggregating Risks for all the possible Accidents that a System might cause,
- Type 4: Aggregating Risks for all the Systems / Facilities / Operations within an organisation,
- Type 5: Aggregating Risks for multiple Systems functioning together (e.g. "System of Systems"),
- Type 6: Aggregating Risks for multiple Systems that may not be independent (e.g. due to "Domino Effects" or "Common Causes").

Typically Risks are assessed from the bottom up starting at the most elemental level (e.g., instrument by instrument) and by risk type (i.e., separately for credit, market and other risks). Risk aggregation rules are primitive: often down to a simple addition of standard deviations, sometimes, a square root of the sum of the squares if there is no evidence of dependency [9, p. 4].

Some firms remain sceptical of the value of these methods and techniques, particularly efforts to reduce all risks into a single number. Others believe that there is a need for a common metric that allows risk-return comparisons to be made systematically across business activities whose mix of risks may be quite different (e.g., insurance vs. trading). However, even among those firms that are at the forefront of exploring economic capital approaches, there is wide variation in the manner in which aggregated risk measures such as economic capital are used for risk management decision-making [3, p. 1].

4   Total Risk

Risk is the result of the cumulative total of all the risks faced by an organization. The estimation of this, however, is difficult because in order to obtain a numeric value, creating a simple sum of the individual risks of its components is not sufficient. The total risk of an entity is a complex relationship of individual risks. It takes into account all possible events which may give rise to risk, hence its estimation is of great importance

for the organization, especially when analyzing the situation. The organization conducts a systematic risk management process, which seeks to ensure the continuation of its activities by analyzing different events (and thus risk). The total risk takes into account the possibility of a variety of different events factored simultaneously in different configurations.

Every entrepreneur who is familiar with the profit and loss statement (one of the three basic financial statements) may on his own try to identify the financial and operational risks in his company. The subsequent sections provide an account of potential sources of operational and financial risks.

„Despite the trendy catchphrase, Total Risk Management has deep intellectual roots in economics, statistics, and mathematics and is based on research that can be traced back to the very foundations of probability theory (Ramsey, 1926), statistical inference (Savage, 1954), and game theory (von Neumann and Morganstern, 1944)" [8, p. 3]. Total risk can be estimated on the basis of definitive analysis of the relationship between the value of sales, operating profit and net profit. Its scale shows us the extent to which the company's net profit will increase due to increased sales values, taking into account financial income and expenditure.

5   Assessment of Total Risk

This article aims to present a useful method of risk assessment, Risk which is generated by numerous events occurring simultaneously. Each event will be illustrated in a document which forms part of the financial statements - the profit and loss account (P&L).

Sample document with comparative variants is shown in Table 1. The natural goal of any company (including non-profit) is to stay on the market, the condition being to obtain a profit in the final outcome (although this alone is not a sufficient condition). Many situations can affect the value of each item of the statement, and thus lead to the destruction of any chance for profit, or a notable loss.

The formalization of this situation is as follows:

- objective: to achieve a given value of profit,
- risk: the possibility of achieving a profit other than the given value.

Event: a situation whose existence has an effect on the objective (its failure).

Table 1. Separate income statement
(*source: self study*)

No.	Item	Sum (zł)	
		This Year	Previous Year
1	2	3	4
A	Net revenues from sales		
B	Operating expenses		
C	Profit (loss) on sales (A-B)		
D	Other operating revenues		
E	Other operating expenses		
F	Profit (loss) on operating activities (C+D-E)		
G	Financial revenues		
H	Financial expenses		
I	Profit (loss) on business activities (F+G-H)		
J	Result on extraordinary events		
K	Gross profit (loss) (I+J)		
L	Income tax (CIT – 19%)		
M	Other statutory reductions in profit (increases in loss)		
N	Net profit (loss) (K-L-M)		

Examples of events affecting individual Profit and Loss Account entries are illustrated in Table 2.

Table 2. Examples of events affecting the profit and loss account
(*source: self study*)

No.	Item	Event affecting objective
1	2	3
A	net revenues from sales	• competition entering the market • weather conditions
B	operating expenses	• increase in costs associated with the consumption of materials and energy • the increase in taxes • salary increases
C	profit (loss) on sales (A-B)	-
D	other operating revenues	• with holding of grants
E	other operating expenses	• loss on disposal of non-financial assets greater than planned
F	profit (loss) on operating activities (C+D-E)	-
G	financial revenues	• unpaid interest • non-payment of dividends, share profits • profit on disposal of investments less than planned
H	financial expenses	• interest • loss on disposal of investments
I	profit (loss) on business activities (F+G-H)	-
J	result on extraordinary events	• extraordinary losses
K	gross profit (loss) (I+J)	-
L	income tax (CIT – 19%)	• increase in Tax rate
M	other statutory reductions in profit (increases in loss)	-
N	net profit (loss) (K-L-M)	-

Table 3. Example separate income statement
(*source: self study*)

No.	Item	Sum (zł)	
		This Year	Prior Year
1	2	3	4
A	Net revenues from sales	68 593	100 000
B	Operating expenses	68 949	60 000
C	Profit (loss) on sales (A-B)	-356	40 000
D	Other operating revenues	1 093	1 000
E	Other operating expenses	594	600
F	Profit (loss) on operating activities (C+D-E)	143	40 400
G	Financial revenues	395 581	30 000
H	Financial expenses	6 019	6 000
I	Profit (loss) on business activities (F+G-H)	389 705	64 400
J	Result on extraordinary events	0	0
K	Gross profit (loss) (I+J)	389 705	64 400
L	Income tax (CIT – 19%)	74 044	12 236
M	Other statutory reductions in profit (increases in loss)	0	0
N	Net profit (loss) (K-L-M)	315 661	52 164

To assess the risk of failure to achieve the given the value of profit, as a result of events affecting the individual items of the profit and loss account, a suitable model should be created which includes the probability of not achieving the objective.

The general model is as follows:

- Profit = (A-B)+(D-E)+(G-H)+J-L-M

  where Profit is the amount obtained by calculations made on the values of the Profit and Loss Account, after taking into account the impact of unforeseen events on its individual components,

- P = P(Profit < Planned_Profit)

  where Planned_Profit is the final value of P&L planned by the company for the current financial year.

6   Case study
6.1   Case study – assumptions

Enterprise X established Profit and Loss Account as follows (see Table 3). Rows A, B, D, E, G and H in the example above are elements of the profit and loss account which may change due to unforeseen events.

Each of them has been assigned a variable symbol:

p_1 – net revenues from sales,

k_1 – operating expenses,

p_2 – other operating revenues,

k_2 – other operating expenses,

p_3 – financial revenues,

k_3 – financial expenses.

The next element of the research conducted takes into account a possible deviation of 20% assumed by the company profit and loss statements for three different distributions of random variables.

Three different scenarios will therefore be explored:

- deviation from the plan of each listed component of the profit and loss of ± 20%, adopting a normal distribution,

- deviation from the plan of each listed component of the profit and loss of ± 20%, adopting uniform distribution,

- deviation from the plan of each listed component of the profit and loss of ± 20%, adopting a triangular distribution.

All calculations will be carried out in the program 'R-project', which is used for mathematical and statistical calculations. It has many built-in features for the quick solution of difficult and complex equations. The following will be used primarily:

- the possibility to use the program as a calculator,

- a random number generator with any distribution,

- rdistributionname (m, distribution parameters),

  where m is a natural number and indicates the amount of random numbers:

  - for normal distribution we have:

    rnorm(m, μ, σ)

    where: μ - mean value for a given interval, and σ - standard deviation,

Table 4. First scenario assumptions
(*source: self study*)

No.	Item	Plan	Possible realization
A	Net revenues from sales	100 000	[80 000; 120 000]
B	Operating expenses	60 000	[48 000; 72 000]
D	Other operating revenues	1 000	[800; 1 200]
E	Other operating expenses	600	[480; 720]
G	Financial revenues	30 000	[24 000; 36 000]
H	Financial expenses	6 000	[4 800; 7 200]
N	Net profit (loss)	52 164	

- for uniform distribution we have:

  runif(m, a, b)

  where: a - the beginning of the interval, b - end of range,

- for triangular distribution we have:

  rtriangle(m, a, b, c)

  where: a - the beginning of the interval, b - end of the interval, and c - middle of range.

- commands counting:
  - mean value mean(w),
  - standard deviation sqrt(var(w)),
  - minimum value min(w),
  - highest value max(w)

  where w is vector of numbers,

- command that allows to calculate the Probability of failure to obtain the planned profit for the company:

  pdistributionname(Planned_Profit, distribution parameters)

  - for normal distribution we have:

    pnorm(Planned_Profit, μ, σ)

    where: μ - mean value for a given interval, and σ - standard deviation,

  - for uniform distribution we have:

    punif(Planned_Profit, a, b)

    where: a - the beginning of the interval, b - end of range,

  - for triangular distribution we have:

    ptriangle(Planned_Profit, a, b, c)

    where: a - the beginning of the interval, b - end of the interval, and c - middle of range.

Since the company cannot be certain of the individual elements of profit and loss, it can only estimate them, which allows the possibility of changing them,

the value of these components will be selected by random selection. In order to validate the calculations performed for each component of the profit and loss account a random 100-element test will be drawn. It should be kept in mind that the sample given in the following case is chosen at random and each subsequent draw will select other values.

According to company plan:

Profit = (A-B)+(D-E)+(G-H)+J-L-M

However if possible causes of changes in the plan are accepted and these changes were randomly selected, then the gross profit is as per formula:

GrossProfit = (p1-k1)+(p2-k2)+(p3-k3)+J

Corporate income tax is:

CIT = GrossProfit*0,19

Finally, net profit is expressed by the formula:

Profit = GrossProfit – CIT.

In Figures 1, 2 and 3 'Profit' is labeled as 'Zysk'.

6.2 Case study - calculation
6.2.1 Scenario 1

Scenario assumptions:

- variation specified in the profit and loss statement differs from the plan values by ± 20%,
- all listed components are random variables normally distributed with parameters μ and σ, where:
  - μ is the mean value to be adopted by variation of the given interval,
  - the value of σ (standard deviation) will be determined by applying the rule of "three sigma", which says that for a normal distribution 99,7% of the features is only ≤ 3 σ, which is within the ranges established in Table 4.
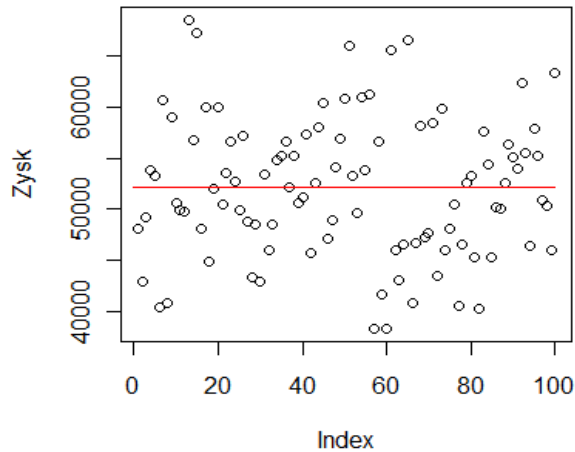
Figure 1. Profit values obtained in scenario 1
(*source: self study*)

We have:

- net revenues from sales are random variable p1 with parameters μ = 100 000 and σ = 6 667 (p1~N(100000,6667^2)),
- operating expenses are random variable k1 with parameters μ = 60 000 and σ = 4 000 (k1~N(60000,4000^2)),
- other operating revenues are random variable p2 with parameters μ = 1 000 and σ = 67 (p2~N(1000,67^2)),
- other operating expenses are random variable k2 with parameters μ = 600 and σ = 40 (k2~N(600,40^2)),
- financial revenues are random variable p3 with parameters μ = 30 000 and σ = 2 000 (p3~N(30000, 2000^2)),
- financial expenses are random variable k3 with parameters μ = 6 000 and σ = 400 (k3~N(6000, 400^2)).

A value is drawn for each of the above, assuming normal distribution, and the result is stored as a variable. The pattern is replicated for the rest of the calculations, leading to a net profit shown in Fig. 1.

Basic measures of location and dispersion for Profit:

- highest profit that the firm may achieve in accordance with the assumptions of scenario 1:

  > max(Profit)
  [1] 68483,24

- minimum profit:
  > min(Profit)
  [1] 38366,13

- average profit with randomly selected parameters:
  > mean(Profit)
  [1] 52027,75

- standard variation:
  > sd(Profit)
  [1] 6784,96

Verification if the Profit function is normally distributed at significance level α = 0,05:

- lillie.test(Profit)

  Lilliefors (Kolmogorov-Smirnov) normality test data: Profit
  D = 0,0523, p-value = 0,7185

Coefficient p-value = 0,7185> α = 0,05, therefore it can be agreed that the sample is normally distributed.

The size of the probability that the financial result achieved will be less than planned:

- pnorm(52164, mean(Profit), sd(Profit))
  [1] 0,5080105

Thus, under the assumptions of scenario 1, the probability of failure to obtain the planned profit for the company will be 50,8%.

Checking how the probability of not achieving any profits changes depending on the size of the sample:

- for 10 randomly selected numbers
  P(Profit <52 164)
  > pnorm(52 164, mean(Profit), sd(Profit))
  [1] 0,4886539

- for 100 randomly selected numbers
  P(Profit <52 164)
  > pnorm(52 164, mean(Profit), sd(Profit))
  [1] 0,5459279

- for 1000 randomly selected numbers
  P(Profit <52 164)
  > pnorm(52164, mean(Profit), sd(Profit))
  [1] 0,4933654

Table 5. Second Scenario Assumptions
(*source: self study*)

No.	Item	Plan	Possible realization
A	Net revenues from sales	100 000	[80 000; 120 000]
B	Operating expenses	60 000	[48 000; 72 000]
D	Other operating revenues	1 000	[800; 1 200]
E	Other operating expenses	600	[480; 720]
G	Financial revenues	30 000	[24 000; 36 000]
H	Financial expenses	6 000	[4 800; 7 200]
N	Net profit (loss)	52 164	

- for 10 000 randomly selected numbers
  P(Profit <52 164)
  > pnorm(52 164, mean(Profit), sd(Profit))

  [1] 0,4950574

- for 100 000 randomly selected numbers
  P(Profit <52 164)
  > pnorm(52 164, mean(Profit), sd(Profit))

  [1] 0,4988596

- for 1 000 000 randomly selected numbers
  P(Profit <52 164)
  > pnorm(52 164, mean(Profit), sd(Profit))

  [1] 0,5004996.

It can be seen from the above calculations that regardless of the multiplicity of tests, the probability of not achieving target profit is about 50%. Common sense should therefore be adopted in the selection of the sample size to allow acceptable times for calculations.

6.2.2. Scenario 2

Scenario assumptions:
- variation specified in the profit and loss statement differs from the plan values by ± 20%,
- all listed components are random variables uniform distributed with parameters a and b, where:
  - a is the beginning of the interval,
  - b is end of range established in Table 5.

We have:
- net revenues from sales are random variable p1
  with parameters $a = 80\,000$, $b = 120\,000$
  (p1~U(80 000,120 000))

- operating expenses are random variable k1
  with parameters $a = 48\,000$, $b = 72\,000$
  (k1~U(48 000, 72 000))

- other operating revenues are random variable p2
  with parameters $a = 800$, $b = 1\,200$
  (p2~U(800, 1 200))

- other operating expenses are random variable k2
  with parameters $a = 480$, $b = 720$
  (k2~U(480, 720))

- financial revenues are random variable p3
  with parameters $a = 24\,000$, $b = 36\,000$
  (p3~U(24 000, 36 000))

- financial expenses are random variable k3
  with parameters $a = 4\,800$, $b = 7\,200$
  (k3~U(4 800, 7 200))

A value is drawn for each of the above, assuming uniform distribution, and the result is stored as a variable. The pattern is replicated for the rest of the calculations, leading to a net profit shown in Fig. 2.

Basic measures of location and dispersion for Profit:

- highest profit that the firm may achieve in accordance with the assumptions of scenario 2:
  > max(Profit)
  [1] 75 164,03

- minimum profit:
  > min(Profit)
  [1] 27 387,52

- average profit with randomly selected parameters:
  > mean(Profit)
  [1] 54 405,42
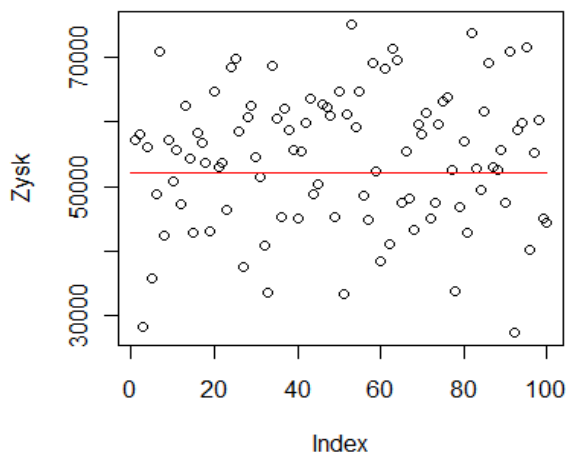
- 2standard variation:
  > sd(Profit) 2
  [1] 10 483,12

Figure 2. Profit values obtained in scenario 2
(*source: self study*)

Verification if the Profit function is normally distributed at significance level $\alpha = 0{,}05$.

- lillie.test(Profit)

  Lilliefors (Kolmogorov-Smirnov) normality test data: Profit

  $D = 0{,}0621$, p-value $= 0{,}4498$

Coefficient p-value $= 0{,}4498$, therefore it can be agreed that the sample is normally distributed.

The size of the probability that the financial result achieved will be less than planned:

- pnorm(52 164, mean(Profit), sd(Profit))
  [1] 0,4153468

Thus, under the assumptions of scenario 2, the probability of failure to obtain the planned profit for the company will be 41,53%.

6.2.3 Scenario 3

Scenario assumptions:

- variation specified in the profit and loss statement differs from the plan values by ±20%.
- all listed components are random variables triangular distributed with parameters a, b, c, where:
  - a is the beginning of the interval,
  - b is end of the interval,
  - c is middle of range established in Table 6.

We have:

- net revenues from sales are random variable p1 with parameters a = 80 000, b = 120 000, c = 100 000
  (p1~Tr(80 000, 120 000, 100 000))
- operating expenses are random variable k1 with parameters a = 48 000, b = 72 000, c = 60 000
  (k1~Tr(48 000, 72 000, 60 000))
- other operating revenues are random variable p2 with parameters a = 800, b = 1 200, c = 1 000
  (p2~Tr(800, 1 200, 1 000))

Table 6. Third Scenario assumptions
(*source: self study*)

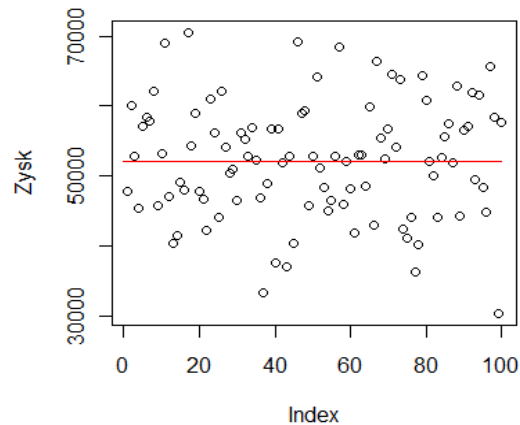| No.	Item	Plan	Possible realization
A	Net revenues from sales	100 000	[80 000; 120 000]
B	Operating expenses	60 000	[48 000; 72 000]
D	Other operating revenues	1 000	[800; 1 200]
E	Other operating expenses	600	[480; 720]
G	Financial revenues	30 000	[24 000; 36 000]
H	Financial expenses	6 000	[4 800; 7 200]
N	Net profit (loss)	52 164	

Figure 3. Profit values obtained in scenario 3
(*source: self study*)

- other operating expenses are random variable k2 with parameters $a = 480$, $b = 720$, $c = 600$ (k2~Tr(480, 720, 600))

- financial revenues are random variable p3 with parameters $a = 24\,000$, $b = 36\,000$, $c = 30\,000$ (p3~Tr(24 000, 36 000, 30 000))

- financial expenses are random variable k3 with parameters $a = 4\,800$, $b = 7\,200$, $c = 6\,000$ (k3~Tr(4 800, 7 200, 6 000))

A value is drawn for each of the above, assuming uniform distribution, and the result is stored as a variable. The pattern is replicated for the rest of the calculations, leading to a net profit shown in Fig. 3.

Basic measures of location and dispersion for Profit:

- highest profit that the firm may achieve in accordance with the assumptions of scenario 3.:
  > max(Profit)

  [1] 70 499,44

- minimum profit:
  > min(Profit)

  [1] 30 355,54

- average profit with randomly selected parameters:
  > mean(Profit)

  [1] 52 304,2

- standard variation:
  > sd(Profit)

  [1] 8 313,398

Verification if the Profit function is normally distributed at significance level $\alpha = 0{,}05$.
- lillie.test(Profit)

  Lilliefors (Kolmogorov-Smirnov) normality test-data: Profit

  D = 0,0481, p-value = 0,8247

Coefficient p-value = 0,8247, therefore it can be agreed that the sample is normally distributed.

For the Kołmogorov-Smirnov's test:

- s.test(Profit,ptriangle,min(Profit),max(Profit),mean(Profit))

One-sample Kolmogorov-Smirnov test data: Profit

D = 0,0942, p-value = 0,3372

alternative hypothesis: two-sided

Coefficient p-value = 0,3372, therefore it can be agreed that

Profit ~Tr(min(Profit),max(Profit),mean(Profit)).

The size of the probability that the financial result achieved will be less than planned:

- ptriangle (52164,min(Profit),max(Profit),mean(Profit))

  [1] 0,539787

Thus, under the assumptions of scenario 3, the probability of failure to obtain the planned profit for the company will be about 54%.

7   Summary

Various aspects should be taken into consideration in risk assessment. This is the reason why this task within risk management involves various scientific disciplines: mathematics, psychology, law etc. The impact on risk assessment by the decision maker is not only a quantitative aspect but also a qualitative aspect.

The application of mathematical and statistical methods for risk assessment presents many benefits but also many challenges. On the one hand, we can use the generation of random variables with a specific,

desired schedule to achieve our objectives; on the other hand, to start working and be able to interpret the results, we are forced to make several assumptions.

In this case, the starting point is a standard Profit and Loss Account, created by each company as an annual statement. It has become the basis for discussion on the impact of various factors on its individual components.

Since it is impossible to accurately plan the future of the individual components of the company's financial results, we can treat these values as random. If, additionally, we are given in advance acceptable deviations from the planned size of profit (loss) and impose on them a particular distribution of random variables, then it is possible, by using the R-project program, to choose random values for all elements of the Profit and Loss Account. The calculation of profit (loss) in accordance with the Profit and Loss Accounting method allows the observation of changes in the business plan resulting from unforeseen random events that affect the individual elements of the financial result. Furthermore, under these conditions it has become possible to calculate the probability that the company will not reach the planned profit in the current year.

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Information for Authors

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Text. The manuscript must be produced clearly on plain A4-sized sheets - 210 by 297 mm. Set top and bottom margins for the pages at 25 mm. Set right and left margins as mirror margins with inside margin at 20 mm and outside margin at 16 mm. The body text must be typed in 10,5pt Times New Roman with 1,15 multiple line spacing and 4pt spacing after paragraph. Figures, tables and formulas should be included in a form which permits editing using MS Word. The title page should include the title of manuscript, author(s), affiliation(s), e-mail(s), abstract (8 - 12 sentences) and key words (8 - 12 characteristic words).

References. References should be quoted in the text using consecutive numbers in square brackets, alternatively, as shown here [1, pp. 7-12], or [2, 4], or [1-3]. At the end of the manuscript, they should be cited as follows:

- The monograph:

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The example:
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- The monograph under the editing:

Author(s) (ed.) - *Title of the monograph*. Publishing company, City and the year of the publication.

The example:
[2]   Ansoff H.I. (ed.) - *Corporate Strategy*. McGraw-Hill, New York 1965.

- The chapter of the monograph under the editing:

Author(s) - *Title of the chapter* [in] Title of the monograph (ed. Authors). Publishing company, City and the year of the publication, numbers of pages.

The example:
[3]   Wilson D.C. - *Organizational Structures in the Voluntary Sector* [in] Issues in Voluntary and Non Profit Management (ed. J. Batsleer, C. Cornforth, R. Paton). Addison-Wesley, Wokingham 1992, pp. 45-93.

- The article in the journal:

Author(s) - *Title of the article* [in] Title of the journal, Volume, Number, year, numbers of pages.

The example:

[4]   Barney J. - *Organizational culture: can it be a source of sustained competitive advantage?* [in] Academy of Management Journal, Vol. 28, No. 7, 1986, pp. 56-65.

- The paper at the conference:

Author(s) - *Title of the paper* [at] Title of the conference, City and the year of the conference, numbers of pages.

The example:

[5]   Bonits N. - *Intellectual Capital: An Exploratory Study that Develops Measures and Models* [at] The First Management Decision Conference, London 1998, pp. 12-20.

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Authors should avoid references to internet addresses with the exception of professional databases which contain articles and monographs.

The example:

[1]   Specialty Publishing Group: *KMWorld Buyers Guide.* KMWorld Magazine, Specialty Publishing Group, www.kmworld.com/BuyersGuide/Default.aspx (accessed on 2011.03.15).

[2]   Ridder H., McCandless A. - *Influences on the Architecture of Human Resource Management in Nonprofit Organizations: An Analytical Framework.* Nonprofit and Voluntary Sector Quarterly, doi: 10.1177/0899764008328182, 2008.

- The reference to the monograph or to an article in a language other than English.

The example:

[1]   Schuster H.G. - *Chaos deterministyczny. Wprowadzenie (Deterministic Chaos. Introduction).* Wydawnictwo Naukowe PWN, Warszawa - Wrocław 1995.