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Framework of performance measurement practices in construction companies in Egypt

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ABSTRACT

Construction industry is considered as one of the most important sectors in Egypt. One of the major challenges faced by the industry, however, is the unavailability of suitable performance measurement systems for assessing companies' performance. Modern performance assessment systems adopt a more universal approach to the measurement of construction company performance as opposed to the traditional project triangle. This paper aims to examine the practice of performance measurement in the Egyptian construction industry. Results show dominant role of in-house developed performance management systems as well as the use of KPIs as a method of performance assessment. The study further reveals that the highest importance is given to measures related to the time of project delivery, quality of works, clients' satisfaction and profitability. Hence, the traditional project triangle of project's success is the most prevalent approach to performance evaluation in the construction industry in Egypt. However, a shift towards a more holistic approach to performance assessment in larger companies was observed.

KEY WORDS
performance, measurement systems, construction, industry, Egypt

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Introduction

Construction companies contribute significantly to the provision of new job opportunities and domestic investment. Therefore, the construction industry is considered as one of the crucial industries in the Egyptian economy behind the agriculture and oil industry (Bank Audi, 2016). Egyptian Centre for Economic Studies (ECES) estimates that Egyptian construction industry (ECI) has employed about 2.7 millions Egyptians between 2009–2014 (approx. 11% of national workforce) (Oxford Business Group, 2017). Similarly, the Central Bank of Egypt (CBoE) estimated that the construction industry's share of the country's GDP was about 4.8% in 2015 (Bank Audi, 2016). It is believed that Egypt is encountering a new development era in the construction sector. The value of the current construction projects agenda is estimated to be around £200 billion. Future plans include the development of one million affordable houses at an estimated cost of about £30 billion as well as the expansion of the Cairo metro line (Oxford Business Group, 2017).

The construction sector in general is considered as one of the among the most inefficient and ineffective sectors (Beatham et al., 2004) mainly due to poor workmanship, materials unavailability, project changes during execution, lack of project information, equipment unavailability and faulty works (Vaverde-Gascueña et al., 2011). Therefore, the construction industry's main concern is to enhance performance by improving the project delivery process. That has resulted in the inclusion of quality and performance management in the management systems of construction companies. In the last decade, the construction industry has started to implement integrated performance measurement systems (PMS) and develop a new approach to maximise companies' performance (Vukomanovic et al., 2007). This paper aims to identify the elements of these performance measurement systems that are being used by Egyptian construction companies.

1. Literature review

Performance measurement has been widely discussed by several researchers, but only a few of them have tried to define the term. Neely et al. (1999) described performance measurement as: "the process of quantifying the efficiency and effectiveness of actions". Where the effectiveness is defined as "the extent to which customer requirements are met and efficiency is a measure of how economically the firm's resources are utilized when providing a given level of customer satisfaction". Traditionally, organisation's performance was assessed on the basis of its financial performance. In the 80s and early 90s, many organisations and industries began to criticise the use of financial measures to evaluate organisational performance and have started to work towards implementing other aspects of performance including quality considerations (Vukomanovic & Radujković, 2007). Generally, performance measurement was associated with quality management as a natural component of evaluation, analysis and control (Abd Elhamid & Ghareeb, 2011). Sharif (2002) argued that the perception and role of performance measurement have changed with the need to answer different organisation's objectives. He argued that answers to simple questions, e.g. "How are we performing?", "What is our cash flow?", "What do our customers think of us?", provide the organisation with business-critical information. However, this leads to evaluating performance following the vague concept of business performance. Sharif (2002) claims that performance cannot be considered in isolation. It is a multidimensional phenomenon, and the process should be subjected to further perspectives to form a complete evaluation of the actual performance. That has justified the introduction of performance measurement systems (PMS). Traditionally, the construction industry maintained to measure its performance from a financial perspective only, neglecting any other influencers of their financial position (Ahmad et al., 2016). However, the performance measurement has started to change with the introduction of one of the project management's leading principles by Matin Barnes. It was the so-called "project's iron triangle" of cost, time and quality performance (Weaver, 2007). This has triggered the development of new performance measurement models which have considered project performance and project-based organisations performance in a broader sense. Those models were based on multidimensional principles.

For decades, the construction industry has been identified as one of the most ineffective and inefficient industries (Latham, 1994; Egan, 1998; Beatham et al., 2004; Tennant & Langford, 2008). Consequently, in 2003, construction companies decided to tackle performance issues by investing around £1.5 billion GBP in performance measurement tools (Vukomanović et al., 2010). In response to the Latham (1994) and Egan (1998) reports, the UK's construction industry created "the single organisation charged with driving the change agenda in construction". The Construction Best Practice Programme (CBPP), thus, emerged in the UK in 1998. Following a series of mergers, the Constructing Excellence was formed in 2003, to create "…a powerful, influential voice for improvement in the built environment sector". CBPP has initiated the first list of 10 Key Performance Indicators (KPIs) to measure performance in the construction industry (Tennant & Langford, 2008). The Construction Excellence (2016) defined Key Performance Indicator (KPI) as "the measure of an activity performance that is critical to the success of an organisation". The following KPIs are predominantly used in performance measurement systems of UK's construction companies:

- client satisfaction – product,

- client satisfaction – service,
- cost predictability (project, design, construction),
- time predictability (project, design, construction),
- defects,
- construction cost,
- construction time,
- profitability,
- productivity,
- safety.

However, Beatham et al. (2004) criticised KPIs. They argue that KPIs could be only applied as a performance measurement tool within a Project Management system. Nudurupati et al. (2007) add that KPIs can be classified as lagging indicators as they measure the actions after their occurrence, so they do not offer an opportunity to change what has already happened, leading to the inability to predict future improvements. Building on the literature review, the authors aim to uncover performance measurement practice and the structure of Performance Measurement Systems in the Egyptian construction industry. Considering certain peculiarities of the construction industry in Egypt, a structure of PMS has been proposed (Fig. 1).

2. Research methods

A survey of construction professionals was adopted, targeting construction companies located in the upper region of Egypt. Questionnaires were distributed to 250 companies operating in the Greater Cairo region, Alexandria and Zagazig. A total of 98 responses were subsequently received. Respondent characteristics are shown in Tab. 1.

Most of the surveyed companies were engaged in construction projects (56%) delivering up 20 projects in the last three years (79%). The sample was equally distributed in terms of company size, average project duration and project value. The respondents were involved mainly in general planning and quantity surveying aspects of their construction projects (43%), with almost 1/3 holding senior management positions.

Respondents were asked to rank the proposed PMS measures as specified in Fig. 1. The rank 1 represented the most important measure of performance, while 7 represented the least important. To present the results, the correspondence analysis was adopted. The correspondence analysis is explorative statistical technique, for representing the relationship and associations between the elements of data sets (Greenacre & Hastie, 1987). The output of correspondence analysis is a graphical representation of the relationships between data categories by plotting them as points in two, three dimensional space. The closer the proximity of a pair of points, the stronger relationship between them.To establish the relative importance of proposed performance measures, the Relative Importance Index (RII) was computed (Eq. 1).

$$RII = \frac{\sum_{i=1}^{N} W_i}{A * N} \quad (1)$$

where:

W — the weight given to each element by the respondents and ranges from 1 to 1, (where "1" is given to element ranked as the seventh and "7" if the element was ranked as first),

A — the highest weight (i.e. 7 in this case),

N — the total number of respondents.

3. Research results

The use of established performance measurement systems is rather low in the Egyptian construction industry (Fig. 2). The majority of surveyed

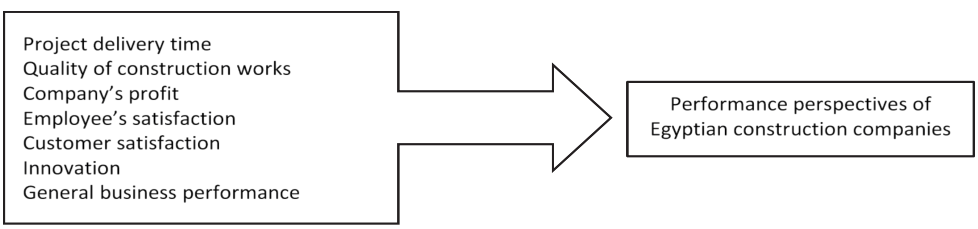

Fig. 1. Research framework for performance measurement in the Egyptian construction industry

Tab. 1. Respondent characteristics

Company size	[%]	Role in project	[%]
Micro	13	General/construction director	32
Small	27	Project managers	25
Medium	23	Planners and Quantity Surveyors	43
Large	37		
Nature of projects	**[%]**	**No of projects delivered in the last 3 years**	**[%]**
Construction	56	Less than 10	43
Repair/Refurbishment	29	10 to 20	36
Civil Engineering & Infrastructure	15	20 to 50	18
		more than 50	3
Average project duration	**[%]**	**Average Project value*, [a]**	**[%]**
Under 6 months	12	<1 mln EGP	12
From 6 to 12 months	27	1 to 5 mln EGP	21
From 13 to 18 months	26	5 to 10 mln EGP	20
From 19 to 24 months	15	10 to 25 mln EGP	15
More than 24 months	20	25 to 50 mln EGP	18
		50 to 100 mln EGP	16
		>100 mln EGP	29
		Don't know	6

Note: *1GBP = 24.67 EGP, [a] – more than one answer was possible.

companies of all size ranges use their measurement systems.

Interestingly, a relatively high share of respondents from medium and large companies do not know how the performance is measured. It could be the effect of the lack of proper information that should have been distributed among employees. It is very unlikely that there is no performance measurement system in use at all. The majority of surveyed companies declared the use of a bespoke, in-house developed performance measurement system. To establish the nature of that system, respondents were asked to describe how the performance is measured. The results are presented in Fig. 3.

Most of the surveyed companies compare their company's performance with data of previous years. The interesting part of this finding is the fact that the data is not finance-related. The data shows that only large companies use performance measurement tools in the assessment of their performance.

To establish the most applicable elements of performance measurement in Egypt, respondents were asked to rank the importance of the system's elements. The correspondence analysis was applied to analyse the collected data. This method requires the selection of the number of dimensions that explain the variability in the dataset. The commonly used rules recommend that the chosen number of dimensions should represent more than 70% of the inertia in data (Higgs, 1991). Our analysis indicated the choice of 15 dimensions that would explain 70% of inertia. However, in that case, interpreting the results would have been almost impossible. Therefore, it was decided that two dimensions explaining 15% of inertia should be adopted. Graphical results of the correspondence analysis are shown in Fig. 4.

The distances of the points in Fig. 4 are informative. The points close together have similar patterns of responses. It appears that the low ranking of quality, time of project delivery and customer satisfaction together with high ranks given to innovation & learning and employee satisfaction have formed a homogeneous subgroup. Moreover, the distance of that subgroup from variables representing the size of investigated companies, indicate their low importance in measuring the performance of Egyptian construction companies. Therefore, the perception of a successful construction company in Egypt is closely related to its product quality, customer satisfaction and the timeliness of delivery. To further extend interpretations and to examine factors influencing the performance measure practice, a second subgroup encompassing company size has been investigated. The similarity in patterns of responses between company size and performance measures is shown in Fig. 5.

Similar patterns of responses for micro and small companies is revealed. The profitability and customer

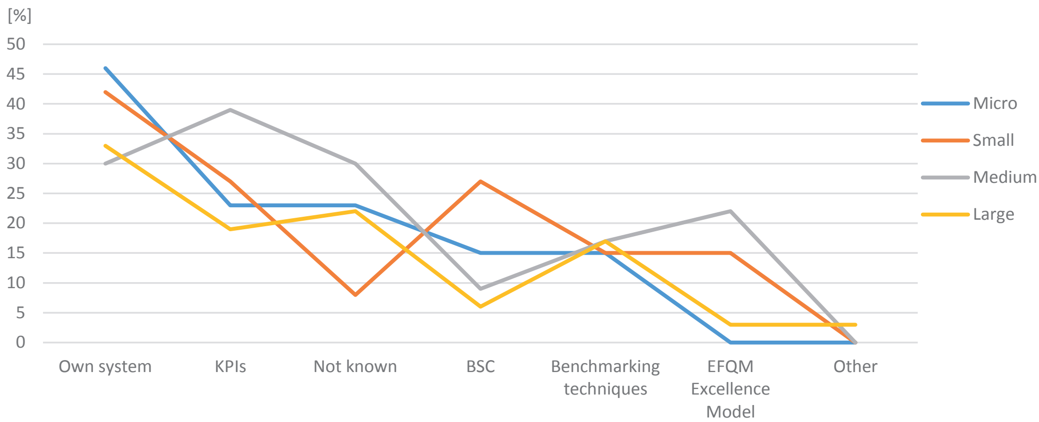

Fig. 2. Use of performance measurement systems in the Egyptian construction industry [%]

Note: BSC — Balanced Scorecard, EFQM — European Foundation Quality Management.

Fig. 3. Character of performance measurement systems in the Egyptian construction industry [%]

satisfaction, which is also expressed in terms of a project delivery time and the quality of construction works, play a key role in the performance assessment. This approach to performance measurement could be described as customer driven. This finding supports the philosophy that micro and small enterprises are often more capable of delivering to customers what is required. That is perceived as the best formula for achieving profit, which seems to be considered, as the best company's performance measure. The position of medium and large construction companies indicates a shift towards a more holistic view of performance measures. Medium and large enterprises are somehow "torn" between the classic time–cost–quality triangle and acknowledging employee satisfaction and general business performance measures. However, a tendency of medium-sized companies towards acknowledging profits as a measure of performance still can be observed. The profile of medium enterprises, as shown in Fig. 5, reveals that more attention in performance measurement system is given to the time of project delivery and profitability than employee satisfaction and business performance. "A look into the future" and organisational development, what could have been expressed with innovation and learning importance in performance measurement, seem to be disregarded by all surveyed companies.

The correspondence analysis has revealed the perception of respondents on the structure of

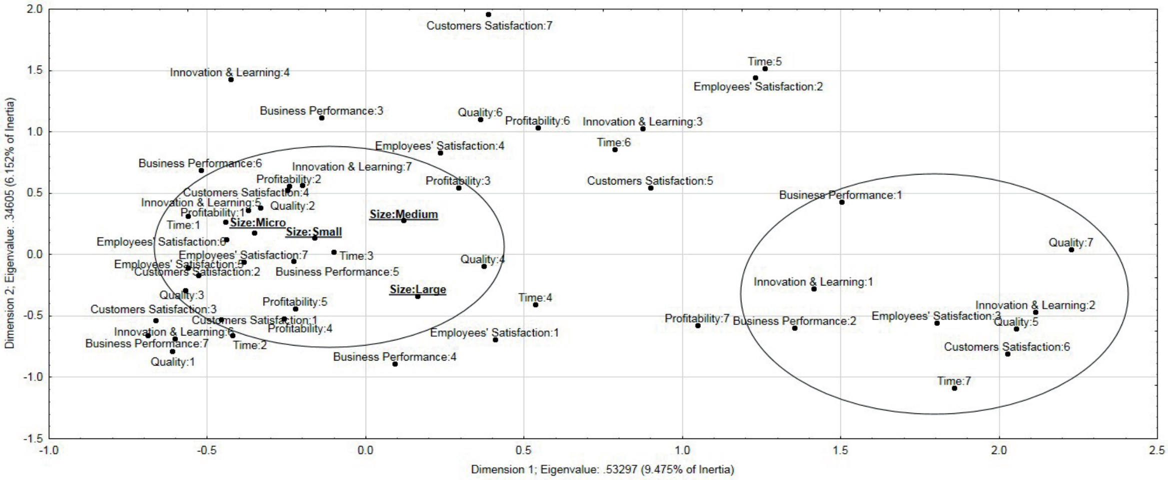

Fig. 4. Profile of performance measurement system in Egyptian construction industry

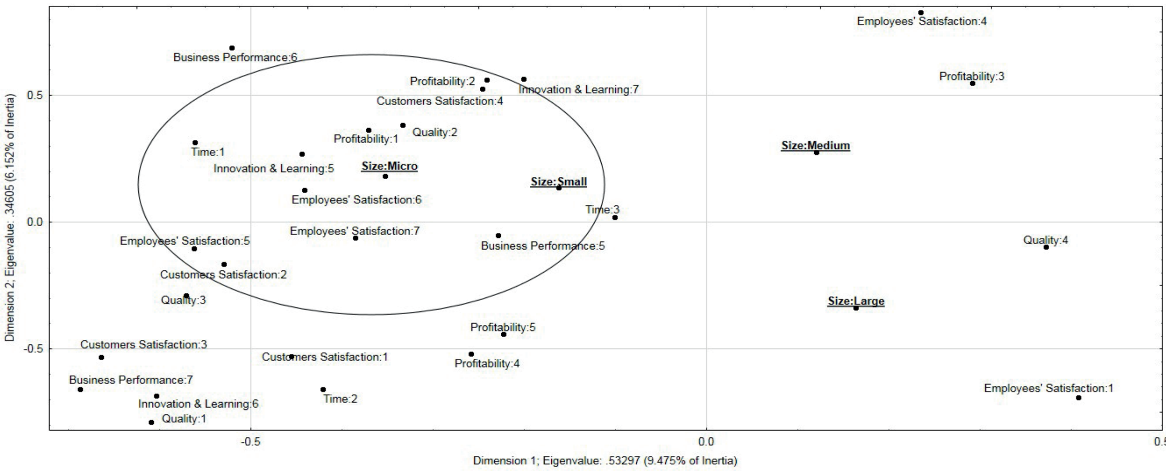

Fig. 5. Profile of the performance measurement system in the Egyptian construction industry (the company size vs performance measures)

proposed PMS. However, to fully understand the performance assessment in the Egyptian construction industry, the contribution of each of elements to the overall structure of PMS in the Egyptian construction industry was examined. To establish the contribution of elements, the Relative Importance Index (RII) was computed. The results of the analysis are shown in Fig 6.

It was assumed, that the components of proposed measurement framework with RII values above 50% cut-off could be considered as significant elements of PMS. Two groups of elements have been identified. The first has the highest observed importance and includes two elements, namely, the time of project delivery and the quality of construction works. Though the significance of time and quality as performance measures diminishes depending on the size of a company, the lowest values of RII in the first group equals to 66%. Customer satisfaction and company's profitability are in the second group of PMS elements. The importance of these elements fluctuates yet oscillates around 60%. The remaining three components (employee satisfaction, business performance and innovation and learning) are below 50% of the relative importance and cannot be considered as measures of the Egyptian construction companies' performance.

4. Discussion of the results

The presented results and findings indicate the dominant share of in-house developed perfor-

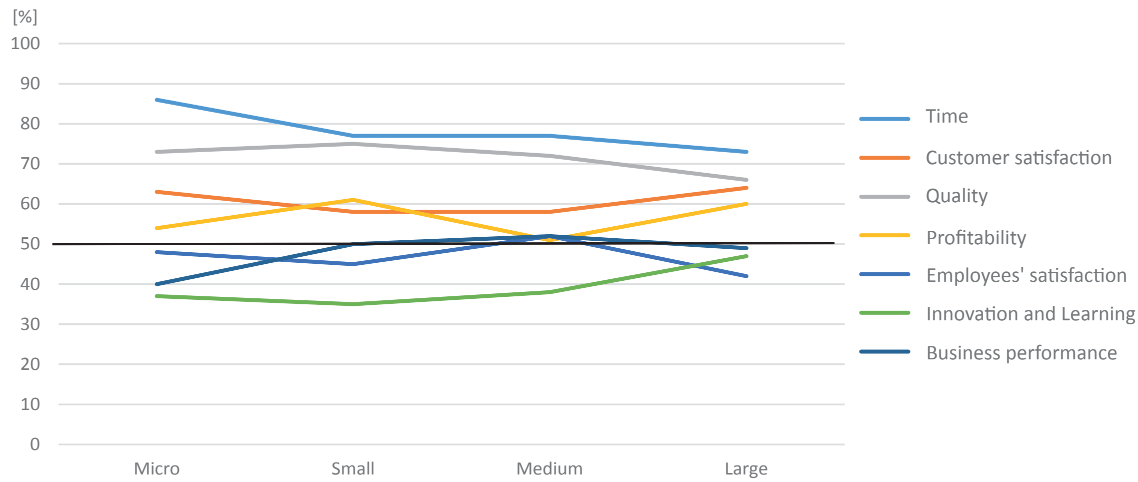

Fig. 6. Relative importance of performance measures in the Egyptian construction industry [%]

mance measurement systems among the surveyed Egyptian companies. Only large construction companies evaluate their performance using the established performance measurement methods. However, the levels of knowledge and use of the established PMSs among large enterprises are low. Results point to KPIs as the most popular method of performance measurement in the Egyptian construction industry. Interestingly, the highest share of KPIs use was observed among medium-sized construction companies (almost 40%). These findings are supported by Hudson et al. (2001) who claimed that the available systems of measuring performance are designed to evaluate the performance of medium to large-sized companies. Neely (1999) explains that SMEs do not use PMSs due to the excessive cost of producing performance measures. Therefore, it is more practical for SMEs to benchmark their performance internally with the measurement of the previous years or by establishing their performance assessment tool. Most of the surveyed Egyptian companies rely on assessing their performance comparing non-financial records with the previous year's results.

The correspondence analysis results revealed a detailed profile of measurement system used by Egyptian companies. Measures of client satisfaction (including the time of delivery and the quality of works) and profitability are perceived as key measures of company's performance. Additionally, the highest importance (measured by RII) is given to time and quality. A profit-driven approach to the company's performance measure is clearly shown.

Although the Performance Management Maturity (PMM) assessment was not an aim of the research, findings could serve as an indicator of PMM level. The Egyptian construction industry can be classified at the premature PMM level (Aho, 2009). That is due to the crucial role of profits and costs in performance assessment. The role of a Performance Management System in surveyed companies is reduced to a simple business support function. However, a shift towards higher levels of PMM can be observed. A gradual inclusion of employee satisfaction and a moderate move towards acknowledging innovation and learning elements in performance measurement systems of medium and large companies indicate the redefinition of PMS's role from business support to business improvement.

Conclusions

The study shows that Egyptian construction companies use their systems and compare results with data from previous years to measure performance. KPIs are mostly used as a method of performance assessment. Results of the study provide a deeper understanding of the components used in practice of performance measurement in the Egyptian construction industry. The proposed research model has been reduced to four components: time of project delivery, quality of construction works, profitability and customer satisfaction. These elements could be clearly related to project management principles (time, cost, quality) which are traditionally associated with project success. Since construction industry is a project-based industry, successful project delivery has the greatest influence on customer satisfaction, hence, a company's profits. Therefore, a company's profit as a performance measure is perceived as the best performance indicator in the Egyptian construction industry.

The developed performance measurement profiles explain only 15% of inertia; therefore, the model needs further validation and development. The inclusion of country-specific elements in performance measurement and enlarging the data sample might improve the quality of the model.

The analysis revealed a difference in the PMS profile and the importance of PMS's elements between SMEs and large companies. However, the causes of that difference are not clear. One of the reasons might be the effect of a company's size and staff-related abilities for data processing. Another could be the globalisation of economic activity and the influence of multinational companies operating in Egypt. Further studies relating to PMS with large companies' management and capital structure could improve the understanding of performance measurement practice in the Egyptian industry.

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Challenges of BIM technology application in project planning

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ABSTRACT

The study aimes at identification of the difficulties in choosing the correct concept of the main building process. The use of a proper BIM design may help the user avoid mistakes and make the building process faster as well as less financial resource intensive. The authors focused on literature review, analysing the difficulties of the BIM design software technology in construction project planning. The biggest flaws in BIM design are inherent in three building process stages: 1) the preparation of a building investment project, and the analysis of the existing situation; 2) the preparation of the building execution technology project; 3) the existing standard processing and information collection in building exploitation period. The analysis shows a persistent need for a deeper BIM design research, to improve information interchange formats that would ensure as much design information saved as possible with ensured feedback. As well as in BIM design, the software packages must be improved by supplementing them with deficient tools or programme codes. After the research of BIM design software, it was determined that architectural, constructional and MEP programs work best interdependently and get analysed the most. These programs work best as they make the least number of mistakes when the model is created in one setting and has many tools. This type of design software data is kept internally, and they are converted into IFC or other information interchange format. Without changing the format, the data is not lost, and this is the reason behind fluent information interchange.

KEY WORDS
BIM, project, building process, difficulties

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Introduction

The building sector, which contains the unconventional building process BIM (Building Information Modeling), is undergoing rapid growth across the world. The linear projection and building management structure could be considered the conventional building process model. In this model, it is possible to segregate projection, planning, realisation and exploitation stages (Fig. 1). The building process based on the BIM method is an unstoppable cycle where stages of the building process and information stream management are prepared as an organisational activity system, at the same time considering transitional design decisions and the final result, which is used for the exploitation and management of the final result after the building process is finished (Fig. 2).

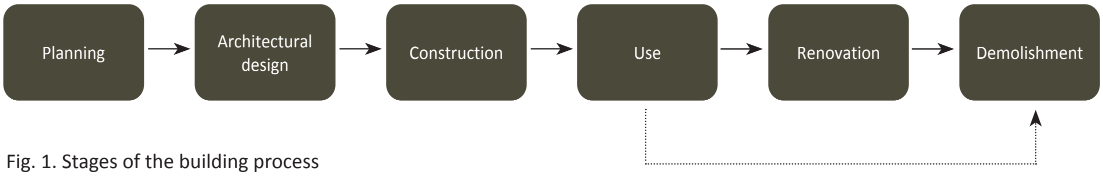


Fig. 1. Stages of the building process

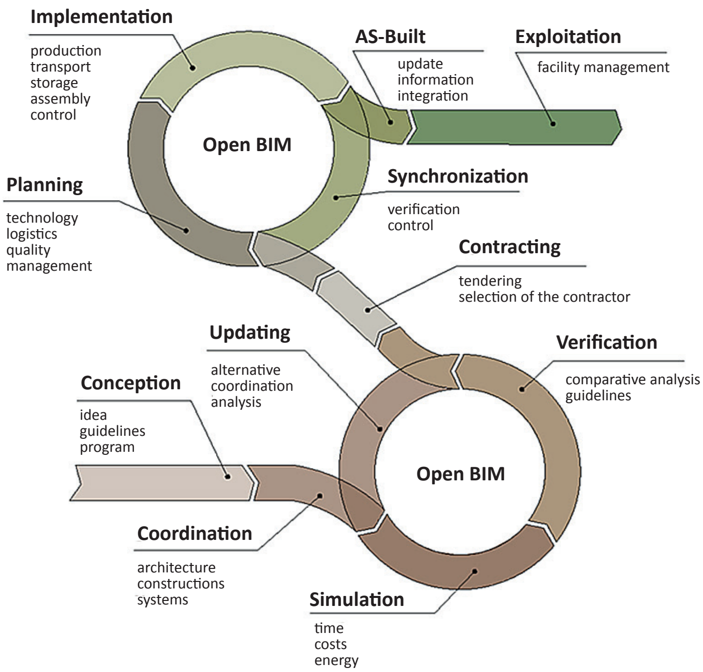


Fig. 2. Building process using the BIM method

The authors of the article (Bryde et al., 2013) carried out an analysis regarding the benefit of using BIM during the design stage. It was determined that the use of BIM has obvious advantages, yet it can be rather unaffordable to some users. Representatives of the construction industry base their decisions to invest in BIM on its expected impact on the construction project performance (Reizgevičius et al., 2018).

The BIM technology (the future technology of the constructions (Harris, 2013)) would help address such issues as high costs, terms of the construction process, life cycle, and design model construction management. BIM is one of the most promising recent developments in AEC industry (Azhar, 2011). According to Talapov (Талапов, 2017), BIM includes more lifecycle phases, integrates program controls, and standardises information management making meanings clear and consistent. It is an additional model for an engineering information database of a project, storing all the architectural designs with geometric information and the corresponding technical information of all work (Ding et al., 2012). The ability to import data on buildings from BIM saves time and reduces uncertainty in building energy modelling process. BIM technology is significantly more labour-intensive compared to a traditional design model. In recent years, efforts have been made to transform the traditional three-dimensional BIM into a four- (4D), five- (5D) or even six- (6D) and seven-dimensional (7D) version based on the application of PLM (Product Lifecycle Management) in the construction sector (Ustinovičius et al., 2015). The 4D technology allows the construction planner to produce the more rigorous schedules (Heesom & Mahdjoubi, 2004; Migilinskas et al., 2013).

Users may avoid mistakes by choosing the appropriate concept of the main building process and using the suitable BIM design (Reizgevičius et al., 2015). This way, the building process becomes faster and financial costs can be reduced. The result of a geometrical design is a model, which is the object of modelling and depends on the chosen geometrical parameters, such as realisation span, expenses, etc. Model BIM facilitates the efficient and automatic creation of some documents, such as data statements, expenses and calendar schedules (projection in 4D and 5D settings) (Tomana, 2016), and substandard tools, such as management of design amendments (Juszczyk et al., 2016; Migilinskas & Ustinovichius, 2006). There are rules in the BIM method that help in the process of integrating human resources connected to building investment projects (Tomana, 2016), in which the main attention is given to organisational and legal aspects in the building project management. BIM allows exploring and optimising various qualitative, financial and graphical aspects while modelling a building. This ensures productivity and more precise predictions that are necessary for productive coordination of various disciplines and creation of optimum workforce. The literature analysis suggests that pieces of design software developed by the same producer interact the best. In these programmes, a fluent information alternation process is ensured, where there is no need for an extra format for information transfer and work is performed in the same model by connecting various tools. These types of programs interact well and, upon selection of an option, can provide feedback when the exported model could be supplemented with information from some other discipline, contained in a different piece of design software; besides, the previous version can be restored without losing the modelled information (Fig. 2).

Nowadays, BIM is used in the building process as combined design software. It is used widely, although the usage of BIM does neither secure a consistent cyclical design nor its use because of several reasons:

- the present BIM design software does not provide common, consistent feedback (i.e. for each stage to be performed, the present BIM design software does not have a common format in most cases; in the process of information transfer from one design software to the other, detailed data may be partially lost);
- some BIM design software does not have a common format for information distribution;
- some fields do not have BIM design software;
- single BIM design software is very expensive;
- users are not able to maximise on the use of all possible options of design software.

To create an efficient building process by uniting all the parts in the BIM setting, it is necessary to set up proper criteria and their order. It is essential to apply the criteria properly, so as the project realisation/creation process would be held as a process analogical to the production (planning and realisation) by using the controlling methods and production quality. In general, the evaluation of investments and the risk analysis are performed in the design stage (through an efficient variant selection). In this version, the planned management actions are performed in a way that the design requirements would be fulfilled by assuring constructional, qualitative, term accomplishment, and budget conditions. Stages of the main BIM building process are united by the process manager. The transitional stage link information must be systematised and described properly using the criteria and functions. BIM enables the exploration and optimisation of various qualitative, financial and graphical aspects while modelling the building. This ensures the productivity and more precise predictions, which are necessary for the productive cooperation of various disciplines and the creation of an optimum workforce. The review of software developed by the biggest BIM design software producers as well as their advancement determined a construction site as the least explored and unfitted environment for the use of BIM, i.e. many BIM design software developers offer programs for the design of a technological project of a building even though it is not fully automated. During the design, a possibility to create models of 3D mechanism and elements is estimated by describing an algorithm. It is possible to simulate the technological process of certain elements. A single technological process description does not cover the complete construction operation and technology. If the process is not analysed properly, rational, optimal solutions are not achieved. This type of building technology design does not optimise the whole process and does not depict the most relevant process which would be evaluated reasonably considering as many real factors as possible. In the design stage in the BIM setting, a prepared building technological project would ensure a faster and more fluent building production helping to avoid mistakes and staying within the planned time framework and the financial schedule.

The purpose of this article is to review and analyse the unified design, construction and operation of a building on the BIM platform by establishing:

- shortcomings of the existing BIM software package interaction between different applications and information exchange actions;

- setting the BIM software package shortcomings as programs to be able to fill the gaps and make the cyclical design process sequential.

1. Joint BIM system analysis and possibilities

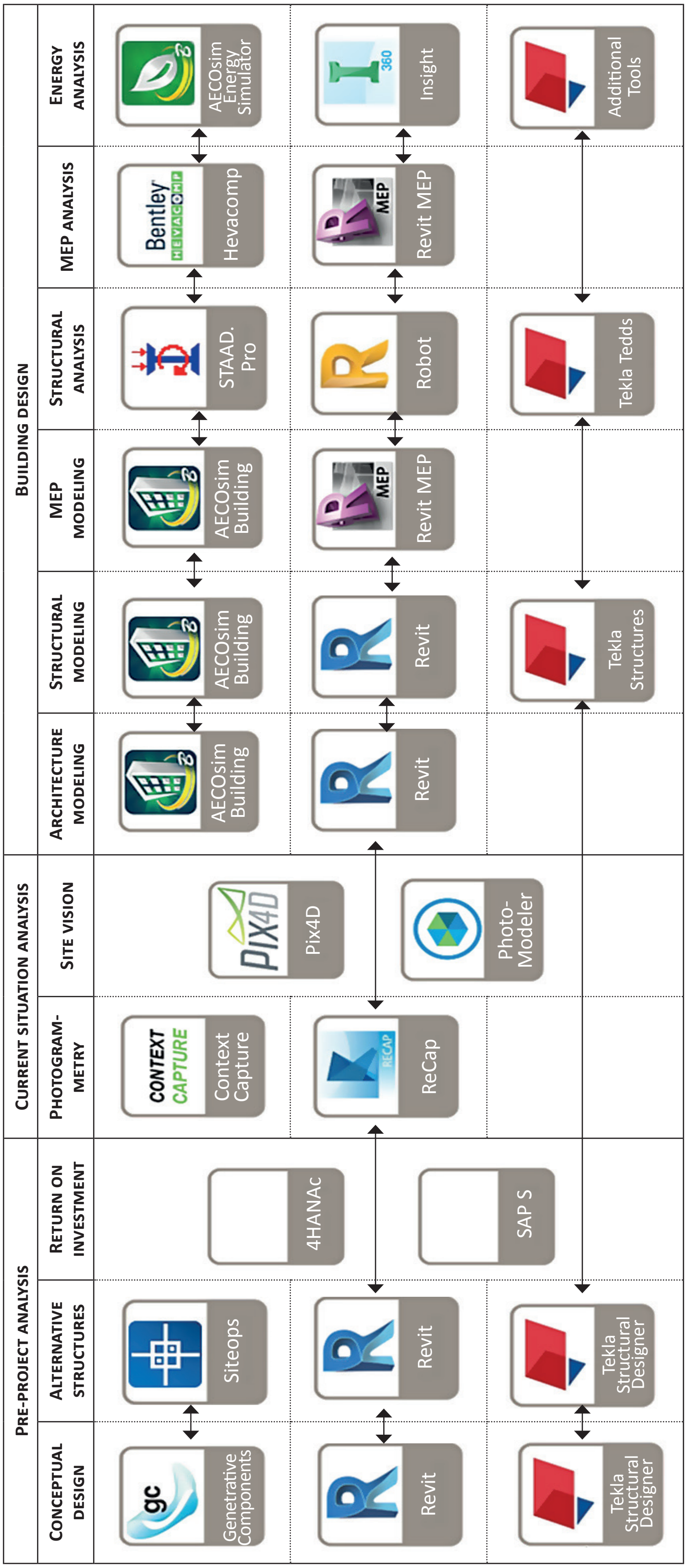
In the study of the disadvantages of BIM systems, the possibilities of BIM packages were analysed by testing their tools in practice and reviewing the literature and program manual. Following the analysis of the existing program reviews and research of their possibilities according to the popularity in the market, three BIM design software producer types were identified: AUTODESK, BENTLEY, and TEKLA. Tab. 1 and Tab. 2 were made based on the analysis of the design software according to their possibilities and areas of use. It was determined that the biggest developers of the BIM software design package do not address the whole building cycle, which is demonstrated in Fig. 2. Based on data, an information interchange map between the programs was created (Tab. 1 and Tab. 2). It was determined that the design software function best when one of BIM packages has more tools and could be used for many tasks without exporting the information to another setting. The analysis of the design software research revealed that in the building process stages building design and project delivery, BIM programs have the widest spectrum of tools that ensure fluent design actions during the stages.

The analysis of the design software map determined that one of the main flaws be the primary ideas for the evaluation using BIM tools. During the building design, the investor's duty is to indicate the project management direction and control it during the whole process cycle by enacting solutions for the project function, shape, budget and the execution term. As well as the expectations and vision of the investors, the project in the stages of building design and exploitation must comply with the standing building standards and rules. To ensure a successful project, all the information must be evaluated at the stage of the primary vision development. One of important example is available from Eastman (2009), namely, an inventory for the design of a primary investment model with the focus on the automation of project stakes so that it would be possible to evaluate and check the proposed primary investment conception according to a certain criterion. A new platform for the BIM investment inspection was created according to a prepared specific criterion, where a described model was uploaded into the system in the IFC format and analysed according to the described criterion and standard requirements. The model complies with the investor's conception, which is checked in the software design with installed BIM tools. These supplementary BIM tools were initiated by the real estate sector to control the risk of investments (Choi & Kim, 2008). It was determined that a proper investment planning using BIM tools requires all the standard documents and requirements would be directly connected to the project to facilitate a thorough project analysis (Greenwood et al., 2010). Hjelseth (2015) described a project evaluation BIM system based on standard documents where standard rules were converted into formulas and data describing rules. This model works properly when the person who designs the model does so according to common system requirements and structure. Ahmed M. Abdel Aziz examined how important economic modelling and risk analysis were for the evaluation of infrastructure and revenue while generating projects such as build-operate-transfer (BOT). The author defines "classifications" of estimating and cash flow methods and develops a summarised model. A classification introduces a particular domain – e.g. construction, revenues, financing, operation and maintenance, or risk analysis – and holds the estimating methods of that domain.

To keep within project budgets, implement programmes, and properly co-ordinate and communicate designs, the design process needs to be planned and controlled. Problems can occur in cases of missing information, poorly communicated information, inconsistencies between documentation, poor resource allocation, poor decision making due to inadequate information, etc. These difficulties have become more prevalent as buildings have become more technical, the range of products and materials has increased, standards and regulations have become more strict, and there is a greater number of specialist designers, particularly in the early stages of the design process.

According to Tab. 1 and Tab. 2, a joint cyclical building process cannot be ensured because of the missing BIM software for automatic building management and building ground. Design tools can be used to visually portray the model of a crane and a chart storage place in 3D dimension. Based on

Tab. 1. BIM design information interchange map



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Tab. 2. BIM design information interchange map

Project delivery				Technology			Construction management		Information for facility management	Asset
Quantity estimate	Material estimate	Work estimate	Design management	Design site preparation process manually	Design site preparation process automatic	Scheduling	Bid	Construction management	Information for facility management	Asset lifecycle information management
AECOsim Building	AECOsim Building		Project Wise Design Integration	AECOsim Building		AECOsim Building	Procure Ware	Project Wise Design Integration	Project Wise Design Integration	AssetWise ALIM
Nevisworks	Nevisworks	SAS	Nevisworks	Nevisworks		Nevisworks		Nevisworks	BIM 360	BIM 360
Tekla Structures	Additional Tools		Tekla BIMsight	Additional Tools		Tekla Structures		Tekla BIMsight	Tekla Field3D	Tekla Field3D

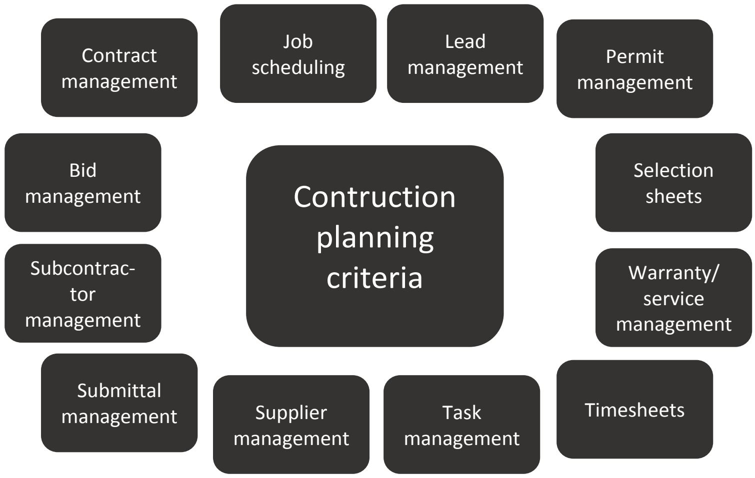

Fig. 3. Main criteria of the most popular program

standard requirements, it is not possible to use BIM design tools to solve building ground preparation tasks (Astour & Franz, 2014). The projectors in BIM setting cannot solve building ground installation tasks, and the results contain many mistakes in comparison to the actual building site. This design must be planned to properly evaluate the construction price and execution period (Tommelein et al., 1992; Rayes et al., 2005). The design of the BIM building process is necessary for the execution of an optimal building plan by analysing all the possible variants and optimising them (Astour & Franz, 2014). It is important to create a large amount of information based on BIM, which would be easily processed and optimised (Trani et al., 2015). Building process management has several stages, including the analysis of the building ground planning and building ground organisation. The organisation part is described using different criteria using BIM, which helps in managing the process and optimising it for all the participants by understanding how the system works in the same way.

Nowadays, it is important to receive timely information and not waste time while searching for documents. Many new pieces of software can help manage and facilitate the building processes.

Bartos researched that high-quality preparation phase of the project leads to the achievement of the defined goals. He also investigated the determination of the project cost using the pricing methods. The author found that automated software helps to model the realisation of construction works for supply creation, preparation and management of the construction process.

Bid Management involves the automated management of bidding for digital marketing campaigns. Bid management tools, also called bid optimisation platforms, enable the automation of small and quick bids for different projects. Bid management is also used to manage bids in the display and market, with the development of real-time bidding. This automated management is possible thanks to algorithms defined by a marketing manager. Sometimes small-size business has time shortage and no recourses for constant monitoring of keyword bids and become the victims of "setting and forgetting" method that causes the loss of money.

One of the most important criteria during construction is the quality of work, billing and invoicing. Martínez-Rojas et al. (2016) described the reason for the dependence of construction projects success on a good access to and management of information. Nowadays, some information is still stored in different databases and even on paper. One of the most important documents in the project management context is the Bill of Quantities. However, a great deal of different types of documents are important in the support of main management tasks.

The author researched that most project information is still stored in different documents and databases and it takes plenty of time while managing all billing and invoicing in every construction. Martínez-Rojas et al. (2016) suggest integrating all this information in a common repository, which is vital for making reliable decisions as well as reducing the time and resources spent to reach these decisions.

Isaac (2017) stated that a considerable proportion of the work in construction projects, as a rule, is performed by different subcontractors. Therefore, it is very important to commit to an effective work packaging process, which is critical for subsequent implementation planning. Almost all construction projects are made of combined networks of elements and supplies that share numerous interfaces. The author suggested close coordination of subcontractors.

Isaac (2017) studied estimates that around 60 and 70% of the value of a project is typically subcontracted. So, the main gage of handling such interfaces boosts due to the reality that an important sum of the work in construction projects is generally held by subcontractors.

The offered general resolution was to directly qualify work packages according to the building systems in the design, to which components belong, despite the difficulty this produces in planning and managing the performance of such work packages.

Contract management is the management of contracts with the participation of customers, vendors, partners or employees. The personnel involved in contract administration required to negotiate, support and manage effective contracts are often expensive to train and retain. Contract management includes negotiating the terms and conditions in contracts and ensuring compliance with the terms and conditions, as well as documenting and agreeing on any changes or amendments that may arise during its implementation or execution. It can be summarised as the process of systematically and efficiently managing contract creation, execution, and analysis for maximising financial and operational performance and minimising the risk.

Job scheduling includes management of land and permit that are the main parts here. Using these tools, it may be helpful to determine the legal fees for all necessary permits for purposes of the budget and project timeline as early in the process as possible; review the complete package of plans and applications for both compliance with laws and regulations; present the information in the way acceptable to the government agency; and ensure completeness of the information in the package; make a critical review of the submission package to determine if any additional steps are necessary in the submission process, e.g. structural sheets may indicate the need for a critical structure review; prepare comprehensive land and building analysis; prepare and manage all plans ensuring they are signed and sealed; review the size, scope and schedule of documents.

Sobieraj (2017) examined, that most project management methodologies should pay much more attention to project planning. When every stage is scheduled during the project planning phase, the project manager can avoid costly mistakes in the imple-

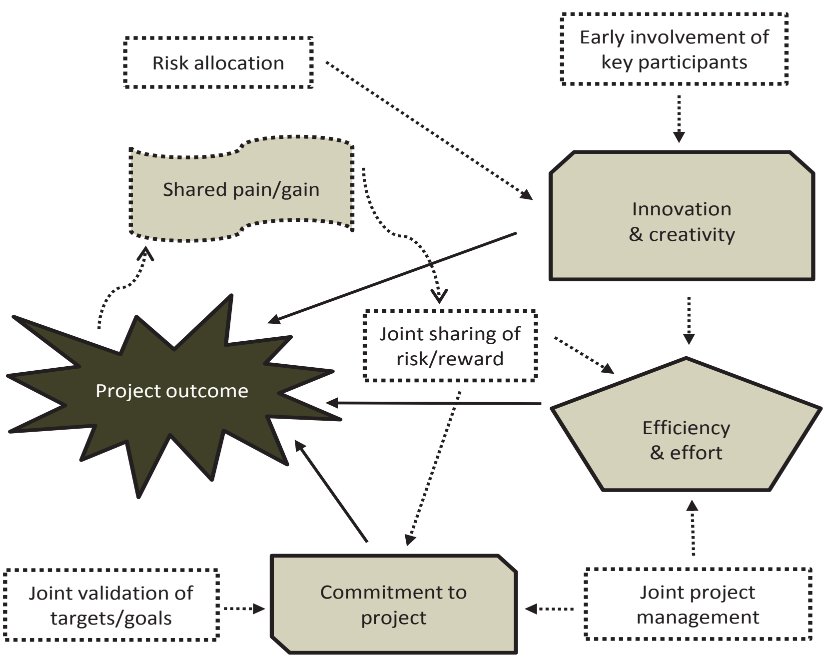

Fig. 4. IPD Structure

Source: (Ashcraft, 2012).

mentation phase. Job scheduling in the initial phase also helps to obviate unnecessary problems and it is possible to realise a project without extra costs.

The author noted the importance of a new innovative approach to the planning process of every project by introducing improvements and innovations.

Lead management is the process of tracking and managing prospective customers. Sometimes, it is referred to as customer acquisition management or contact management. The process of managing leads helps businesses understand, which tactics are bringing in the best results, so it is the way to optimise the sales strategy to be effective and efficient (Ejdys, 2014).

Moreover, since lead management documents a person's full history of interactions and experiences with the company, it becomes possible to analyse exactly how a person was converted from a prospect to a lead and a customer.

Fink (2014) described that a lead manager's competence in a construction project performance is mainly influenced by reaching internal and overall budget, quality and deadline goals. She noted the importance of achieving the final goal and explained how it depends on project manager's skills. By the way, a lead project manager needs help from stakeholders, their business relationships and the whole team. The author emphasised the significance of the timetable and planning as any defects in the initial phases could have extensive effects on the last stages.

In relation to Permit Management, it is important to note the common rule that building permits are necessary to start a construction project. But every jurisdiction has more or less subtle differences in zoning, laws, regulations, building codes, and requirements. It becomes clear when it comes to presenting architectural drawings and plans. These aspects can determine the difference between a project sailing through the process with minor revisions or experiencing major delays. Changes and adjustments to the complex design and construction project are carried out continuously. The design process and conditions are constantly changing; therefore, constant design documentation must be checked against the existing regulatory documents. Due to these circumstances, the entire legal information on the project must be structured and aligned in a suitable format so that the design has no errors.

Online platforms of selection sheets provide a possibility to collect customer data without stress and frustration. Homeowners can log in online to make and approve their selections. Once they are done, contractors are alerted about the newly approved selections and can easily track allowance overages, etc. Online selection sheets may allow:

- setting due-by dates to keep homeowners on schedule for their selections,
- receiving notifications as selections are approved,
- having a conversation in each selection's comment feed,
- transforming approved selections into change order contracts,
- tracking overages and allowance vs. the chosen figures,
- saving selection sheets to templates for future use,
- importing to and exporting from Excel.

Subcontractor Management is the management of outsourced work performed for an individual company. Contractor management implements a system that manages contractor's health and safety information, insurance information, training programmes and specific documents that pertain to the contractor and the owner/client. The majority of nowadays contracts require the effective use of contract management software to aid the administration between multiple parties. Risks increase with the loss of control from outsourcing work. With the ongoing outsourcing of production, companies put a lot of effort into standardising their contractor management processes.

Arashpour (2017) considered that the optimisation of supply decisions enables off-site manufacturers to achieve high production performance with a smaller supply investment. The author also analysed how optimisation of the provided solution under uncertainty is formulated, and cost of adopting multi-supplier configurations to address uncertainty is optimised.

Arashpour explained three research hypotheses mainly on the optimisation of submittal management and configurations are developed and tested. It is very important to realise that the progressive fabrication of building products is not a self-contained work, and cooperation with the provision of networks is always required. According to the author, the complexity and comprehensiveness of supply networks in off-site manufacturing justify this assumption.

Supplier Management. The main key to the effective supply chain is supplier management. It helps to account and optimise supply chain properly. "Suppli-

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ers sit at the heart of almost every organisation's activities and processes" (Smith, 2014).

If a company has the vision to run as it should, it must ensure the seamless flow of goods and products.

Shi et al. (2016) analysed how construction supply chain management achieved rapid progress over the past decades. He stated that, as a result, the traditional internet file is to fulfil the demands for real-time information sharing and communication derived from various construction supply chain members. The article by Shi et al. (2016) provides an overview of research methods adopted in the field of construction engineering and management, including survey, observation, case study and experiment.

The author provided the theoretical contribution to the development of an integrated framework in this research domain. He also explained how important it is to fill gaps in the existing body of knowledge and identify the future research.

Task management software helps a company to manage large projects effectively and on schedule. The system helps to generate feasible targets and deadlines in line with the data included in the application. Plus, it can be linked to interdependent tasks for seeing the whole picture and making sure the team deliverables balance out rather than contradict one another. Task management can be used as software to predict problems and opportunities and reorganise the methods and resources according to the changing circumstances. The system can help to achieve the goals and objectives no matter what type of a project. In assigning tasks, it is important to allocate work properly according to available resources. BIM enables these processes to be optimised while minimising human resources. According to the common practice, resource allocation can be done according to an appropriate production plan (Fig. 5).

Kuenzel et al. (2016) presented some methods that promote project task management with real-time communication on the construction site, including processes and performance of machines and staff.

The authors claimed that multi-agent systems remain as a promising practice for automated site task management, which reduces the centralised, strictly hierarchical work portfolio of a traditional site manager.

His article takes over techniques from the range of divided artificial intelligence, namely, multi-agent frames, to promote a method that automatically generates instructions for human operations. The method

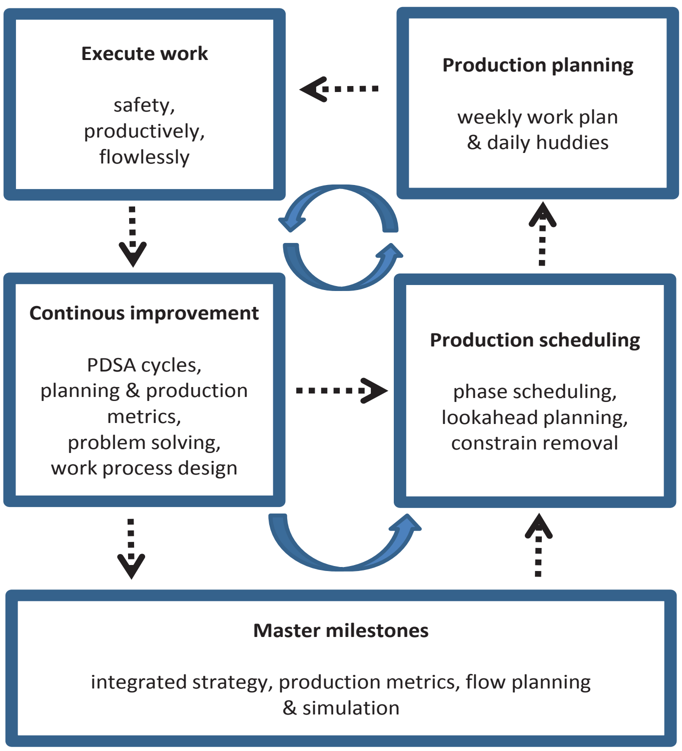

Fig. 5. Production management scheme

Source: (Fisher et al., 2017).

can react to variable and changing site task management conditions.

Service Management delivers integrated work-order management for more efficient processing of service and small job work. Using service management, a company can stay on top of the maintenance work, streamline tracking of equipment maintenance, facilitate renewals and simplify the billing process.

The main goal of high-performance service management is to optimise the service-intensive supply chains, which are usually more complex than a typical finished-goods supply chain. Most service-intensive supply chains require larger inventories and tighter integration with field service and third parties. They also must accommodate inconsistent and uncertain demand by establishing more advanced information and product flows. All processes must be coordinated across numerous service locations with large numbers of parts and multiple levels in the supply chain.

Crnković and Vukomanović (2016) considered how effectively project risk management could help to ensure a significant impact on the success of project goals and lower warranty costs in the future. He also explained how important are knowledge, experience, communication and understanding in all stages of a project. Once construction project is done, it is time for service the management stage.

In conclusion, the authors explained how to establish quality connections between theory and practice to improve the philosophy of risk management by using legal provisions to make risk management an obligation for every Project. These criteria are based on a table of five most popular design programs (Tab. 3).

The literature review revealed that one software package is not enough for designing and analysing the energy efficiency of a building. Gerrish et al. (2017) use the Dynamo program to output data from the REVIT BIM environment to JavaScript Object Notation (JSON). Any information conversions have weaknesses due to the loss of data content and completeness, and there is no complete reciprocal linkage with the results obtained in the original model.

The method using an active BIM model is innovative and may bring significant benefits for building management. Simulations of building behaviour allow designing the appropriate shape of the building as well as the use of relevant materials and engineering systems, ensuring safe and comfortable use of the building in the future. Successful management of any innovation largely depends on identifying the critical determinants of innovation performance.

Benefits identified during the construction phase include less rework, reduction in requests for information and change orders, customer satisfaction through visualisation, improved productivity in phasing and scheduling, faster and more effective construction management with easier information exchange, accurate cost estimation, and visualising the safety analysis (Eastman et al., 2008; Hardin, 2015; Elbeltagi & Dawood, 2010; Azhar, 2011; Hartmann et al., 2012). During the operation phase, this technology includes control of facilities management progress, integrated life-cycle data, rapid and accurate information of updating and changing activities, and more effective facility management with easier information exchange (Eastman et al., 2008; Hardin, 2015).

This system gives the ability to model changes in the structure of the building, re-design building with new engineering equipment, bringing its performance up to date requirements, monitor the current status of the building and take timely action for the restoration, competently operate existing facilities' Both technologically and economically, BIM is an additional model for a project's engineering information database, storing all the architectural designs with geometric information and the corresponding technical information for all the works (Ding et al., 2012).

BIM construction standardisation not only contains the geometry of walls, columns, beams, doors, windows, and other building components, but also contains specific attributes for each object, such as material type, material properties, and vendor.

Updating the as-built schedule during the construction phase is generally recognised as the most critical strategy for successful Schedule management (Tserng et al., 2014).

It is required to exchange and deliver intelligent 3D models through all project stages. All plan files and 3D models should comply with the project elevation and coordination system. For BIM use in project delivery, there should be logical object structure and classification system (standards and regulations). For project control in all stages, it is needed to control not only 3D models but also documents, construction processes, etc. Therefore, it is important to manage late changes in a project, provide accurate information for construction, work with many different stakeholders, and create high-quality records for long-term maintenance (Fig. 7).

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Tab. 3. BIM design programs used in construction

		Top 10 software of Construction Management by construction planning criteria				
		ePROMIS Construction ERP	Paskr Project Management Suite	Snappii Mobile Apps	Tenderfield	MySmart-Plans
		SimpleBuild	GamePlan	4PS Construct	Builder-Console	BuilderEdge
Construction planning criteria	Bid management	+	+	+	+	+
	Contract management	+	+	+	+	+
	Job scheduling	+	+	+	+	+
	Lead management	+	+	+	+	+
	Permit management	+	+	+	+	+
	Selection sheets	+	+	+	+	+
	Subcontractor management	+	+	+	+	+
	Submittal management	+	+	+	+	+
	Supplier management	+	+	+	+	+
	Task management	+	+	+	+	+
	Timesheets	+	+	+	+	+
	Warranty/service management	+	+	+	+	+

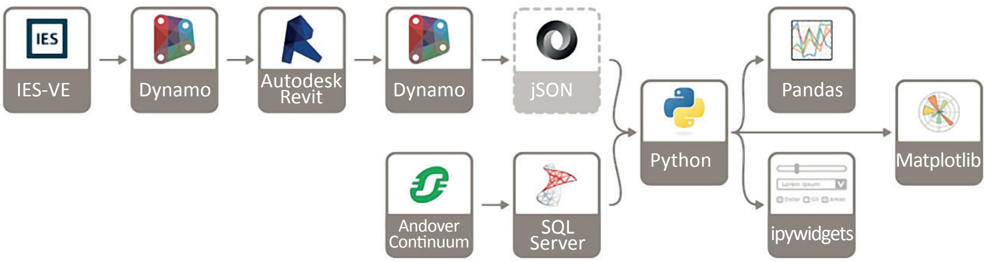

Fig. 6. Building energy calculation path in the BIM environment

Source: (Gerrish et al., 2017).

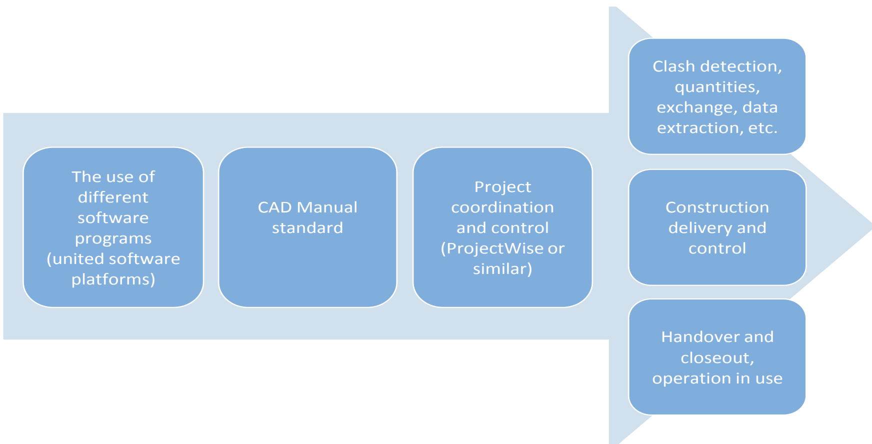

Fig. 7. Project delivery strategy

2. Information interchange between pieces of BIM designs software (handover)

The analysis of the existing pieces of design software and their possibilities demonstrated that the biggest problem is the information distortion and discrepancy after trying to transfer it from one program package to another. This flaw emerged in the BIM packages offered by the same developer because different design software groups require different information sets to perform a task. After the export of the model into a design software format, not all the information was transferred, and after the import of the model, not all the information was recognised. This flaw emerged due to the incompatibility of information structure and content (Vlayton et al., 1999). According to Becerik-Gerber et al. (2012), BIM must be evaluated as an object having a strict structure, corresponding to standard documents and described according to the same criteria. The transfer of the information without defined specific requirements does not ensure the reliability of the transferred information. The best BIM result was achieved using one package for projections, where the created model could be analysed with many different BIM function tools. During this type of projecting, it is not necessary to convert the model into information format, which enables saving the data and ensuring the reliability.

Conclusions

Following the analysis of BIM design software research, it was determined that architectural, construction and MEP programs work best interdependently, and they are analysed the most. These programs work best as they make the least number of mistakes when the model is created in one setting and has many tools. This type of design software data is kept internally and converted into IFC or other information interchange format. The data remains unlost as long as the format remains unchanged; therefore, a fluent information interchange can be performed. The greatest flaws in BIM design emerge from three building process stages:

- the preparation of the building investment project and the existing state analysis,
- the preparation of the building execution technology project,
- the existing standard processing and information collection during the exploitation of the building.

The analysis shows that more research efforts on the BIM design are required to improve information interchange formats to save as much design information as possible and have feedback. As well as in the BIM design, software packages must be improved by supplementing them with deficient tools or program codes.

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Fast truck-packing of 3D boxes

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ABSTRACT
We present formulation and heuristic solution of a container packing problem observed in a household equipment factory's sales and logistics department. The main feature of the presented MIP model is combining several types of constraints following from the considered application field. The developed best-fit heuristic is tested on the basis of a computational experiment. The obtained results show that the heuristic is capable of constructing good solutions in a very short time. Moreover, the approach allows easy adjustment to additional loading constraints.

KEY WORDS
container packing, 3D-packing problem, heuristics

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Introduction

Global economy and competition require optimisation of the logistic chains. Transportation costs constitute a significant part of overall logistic chain operational cost. There are two major features influencing the operating costs of a transportation system. These are route and vehicle load planning. Since optimal utilisation of the load space of a vehicle may bring significant savings and contribute to decreasing the pollution of the environment, it is an extensively examined research topic. In parallel, in response to the practical needs, several software systems have been developed in this area.

The container packing problem being a special case of the three-dimensional packing problem belongs to the family of cutting and packing problems. The latest and widely cited classification of cutting and packing problems was given by Wäscher et al. (2007). In this classification, the container loading problem is the three-dimensional rectangular Single Large Object Placement Problem (SLOPP).

The vehicle loading problem is usually modelled as a three-dimensional packing problem with heterogeneous items of regular shapes. The shape of an item is a parallelepiped. Two versions of the problem are considered in the literature. In the first one, the knapsack version, the container space available is fixed, and the goal is to maximise the weight of the packed items while some items may be left unpacked. In the second version, the bin-packing, the goal is to minimise the number of containers while all the items have to be packed. The problem, called the container packing problem, is well known to be NP-hard (Garey & Johnson, 1979), so the main interest is to find a good heuristic to solve it.

Although several approaches have been proposed in the literature (we present some of them in more detail in the next section), none of them considers all real-life constraints following from the product characteristics, delivery terms or other company-specific features discussed in Section 1.1. On the other hand, the commercial software available produces solutions far from optimality.

The goal of this research is to develop a fast and effective heuristic for solving the container packing problem flexible enough to produce solutions respecting various types of real-life constraints. The paper is organised as follows. In Section 1, we present the MIP formulation of the considered problem. Section 2 contains a description of the proposed heuristic algorithm. Results of computational experiments are provided in Section 3. The last section summarises the work.

The motivation for solving the practical problem comes from a factory producing household equipment. This factory produces goods such as washing machines, fridges, ovens, microwaves etc. These goods are packed into paralepipedic cartoon boxes. Client orders are serviced by the sales and logistics department. However, customers can order goods in many different ways such as by the e-mail, fax, even telephone or by a specific web application. One of the most important issues for customers is the transportation cost which depends on the container size and the optimal usage of the space in the container. Additionally, various constraints restricting the way of transporting this kind of goods are to be considered. There are constraints connected with the stability of the load in the container or the placement of boxes in the container, such as the dependency restriction that means, for example that the washing machine box cannot be placed on the kitchen oven box. Moreover not all rotation axes are possible, e.g., the fridge cannot be placed upside down. In our case, the assortment of the products is also somewhat wide, but for one transportation order, it does not exceed twenty different types of products.

Direct clients of the factory are re-sellers, supermarket chains, wholesaler, outlets and retailers placed all over the world. Clients usually do not know or do not specify the placement of goods in containers. Hence the necessity to construct a heuristic algorithm able to produce a high quality solution within time that must not exceed two minutes. Such an approach has not been studied in the literature where many models do not respect real constraints such as product stability and box dependency.

We focus on a quickly generated solution with acceptable container space usage. Input data is the order list. The seller's work is to negotiate order lists, adjust them, usually by decreasing the number of loaded goods. Sometimes, the consultation of the packing experts is necessary to deal with the transportation constraints and reduce the transportation cost paid by the customers. After being accepted by the seller, the packing list is generated. Subsequently, the packing list is transferred to the storage accompanied by the packing order and 3D visualisation of how the purchased products should be placed in the container to reduce the additional free space usage.

The selling process is considered to be changed. The customer should be able to construct the final order list using the web application allowing him to compose the packing solution for the specific container. After acceptance, the final packing list is sent to the storage. The application is directly connected to the assortment database, and an authorized customer can make an order considering its distribution in the containers and trucks. The system significantly reduces the factory's operating and personnel costs. Moreover, it allows a deeper analysis of client orders from the transportation point of view.

1. Problem formulation

1.1. Basic MIP model

Let us consider a rectangular cuboid (parallelepiped) container of dimensions (D_x, D_y, D_z) and a set of n parallelepiped items (boxes) of dimensions (d_{li}, d_{wi}, d_{hi}), $i = 1, \ldots, n$. The basic container packing problem is to find a subset of boxes and their positions in the container so that the total volume of the boxes packed is maximised. In a feasible solution, all items must be fully inside the container and no two boxes may overlap. Fasano (2008) proposed the following MIP formulation of the above problem calling it it "the basic problem". To build the MIP model, let us assume that the container is included in the positive quadrant of an orthonormal reference frame (x, y, z) with the origin O that coincides with one of the corners of the container. Moreover, the sides of the container as well as of all the boxes inside are parallel to the reference frame axes (x, y, z). The position of box i may be thus defined by giving the coordinates (c_{xi}, c_{yi}, c_{zi}) of its geometrical centre (we assume that it coincides with the mass centre) and binary variables $\delta_{\alpha\beta i}$, $\alpha \in \{l, w, h\}, \beta \in \{x, y, z\}, i \in \{1, \ldots, n\}$ where

$$\delta_{\alpha\beta i} = \begin{cases} 1 & \text{if side } \alpha \text{ of box } i \text{ is parallel (same orientation) to axis } \beta, \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Binary variables χ_i, $i = 1, \ldots, n$, indicate whether box i is packed in the container.

$$\chi_i = \begin{cases} 1 & \text{if box } i \text{ is packed,} \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

Although various objectives may be considered, the one used most often in logistic applications is to maximise the volume of boxes packed (3):

$$\text{maximise} \sum_{i=1}^{n} d_{li} d_{wi} d_{hi} \chi_i \quad (3)$$

The constraints considered in the basic model guarantee that each side of every box is parallel to one side of the container, all boxes packed are fully contained inside the container, and that the boxes do not intersect. These constraints are formulated as follow.

The orthogonality constraints (4) and (5) ensure that exactly one side of a packed box is parallel to each axis, and each axis is parallel to exactly one side of the packed box.

$$\sum_{\beta \in \{x,y,z\}} \delta_{\alpha\beta i} = \chi_i, \alpha \in \{l, w, h\}, i = 1, \ldots, n \quad (4)$$

$$\sum_{\alpha \in \{l,w,h\}} \delta_{\alpha\beta i} = \chi_i, \beta \in \{x, y, z\}, i = 1, \ldots, n \quad (5)$$

The domain constraints (6) must hold for each $\beta \in \{x, y, z\}$ to guarantee that each packed box is fully contained in the container.

$$0 \le c_{\beta i} - \frac{1}{2} \sum_{\alpha \in \{l,w,h\}} d_{\alpha i} \delta_{\alpha\beta i} \le c_{\beta i} + \frac{1}{2} \sum_{\alpha \in \{l,w,h\}} d_{\alpha i} \delta_{\alpha\beta i} \le \chi_i D_\beta \quad (6)$$

Finally, the non-intersection constraints (7-9) imply that any two boxes packed do not intersect. They hold for $\beta \in \{x, y, z\}, i, j \in \{1, \ldots, n\}, i < j$.

$$c_{\beta i} - c_{\beta j} \ge \frac{1}{2} \sum_{\alpha \in \{l,w,h\}} (d_{\alpha i} \delta_{\alpha\beta i} + d_{\alpha j} \delta_{\alpha\beta j}) - (1 - \sigma^{+}_{\beta ij}) D_\beta \quad (7)$$

The binary variable $\sigma^{+}_{\beta ij}$ is introduced to detect the situation where boxes i and j are packed in the container, they do not intersect along axis β, and j precedes i, (i.e. $c_{\beta j} < c_{\beta j}$). If this is not the case ($\sigma^{+}_{\beta ij} = 0$), the constraint (7) is trivially satisfied. If i precedes j, the corresponding non-intersection constraints are formulated as follow:

$$c_{\beta j} - c_{\beta i} \ge \frac{1}{2} \sum_{\alpha \in \{l,w,h\}} (d_{\alpha i} \delta_{\alpha\beta i} + d_{\alpha j} \delta_{\alpha\beta j}) - (1 - \sigma^{-}_{\beta ij}) D_\beta \quad (8)$$

The binary variable $\sigma^{-}_{\beta ij}$ has a similar interpretation as $\sigma^{+}_{\beta ij}$. To guarantee that if both i and j are packed at least one of the non-intersection constraints holds, we introduce constraints (9).

$$\sum_{\beta \in \{x,y,z\}} (\sigma^{+}_{\beta ij} + \sigma^{-}_{\beta ij}) \ge \chi_i + \chi_j - 1, i, j \in \{1, \ldots, n\}, i < j \quad (9)$$

Other MIP models of the basic container packing problem were given by Onodera et al. (1991), Chen et al. (1995), Padberg (1999), Fasano (1999), Fasano (2004), Fasano (2008), Pisinger and Sigurd (2005).

1.2. Additional constraints

Many authors conclude that the basic model does not consider numerous constraints that occur in real-life container loading problems. Those constraints may be caused by the product characteristics (e.g. nothing else may be packed on top of the product because it is fragile), the loading process (by fully automated loading, some additional space is required for the manoeuvres of the loading equipment), vehicle carrying the container (different requirements for car and rail containers) etc. Although this need is widely recognised, only few heuristic approaches address the above issues explicitly.

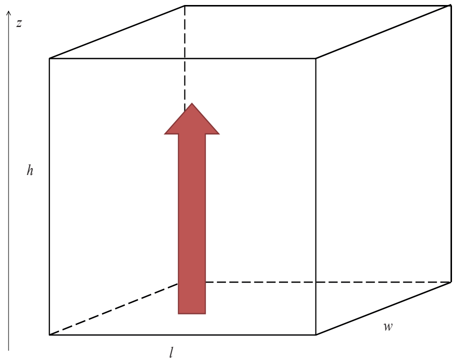

Fig. 1. Box orientation

The first systematic survey of practically justified requirements affecting the container load was presented by Bischoff and Ratcliff (1995). Below, we give a short survey of additional constraints related to the allocation of boxes or box size, the mass of the boxes and load stability.

1.2.1. Volumetric constraints

Volumetric constraints are generally considered by the basic formulation. The sizes of the container and boxes are basic data for the loading problem. It is often the case that a box must be positioned with exactly one side at the top as shown in Fig. 1. It is easy to model fixed (or partially fixed) orientation of boxes. To fix the orientation of box i, it is enough to fix the values of the corresponding $\delta_{\alpha\beta i}$ variables. We may conclude that all MIP formulations and most of the construction heuristics allow fixing the orientation of boxes and so does our method as well.

1.2.2. Mass constraints

One of the very important constraints sometimes considered as an objective is related to the maximum mass of the loaded items (10). In some situations, the maximum load of the carrying vehicle may be limited. It is the case for tucks since in many countries the maximum load is regulated by law. Such a constraint may be naturally modelled by adding the following constraint:

$$\sum_{i=1}^{n} m_i \chi_i \leq M, \tag{10}$$

where m_i is the mass of box i, $i = 1, \ldots, n$, and M is the maximum load of the container.

Moreover, in some applications (aircraft loading or a container moved by a crane), the distribution of mass is a crucial issue. Another limitation may follow from the bearing strength of a box and may be expressed as the maximum weight of boxes packed on top of a given box.

1.2.3. Layer constraints

In many practical situations, loading constraints require that some boxes have to be placed on the floor, or nothing else may be placed on top of some fragile boxes. In general, some relation may be defined on the set of boxes showing if box i may be placed on top of box j. We represent this relation by a directed graph G, where arc (i, j) belongs to the graph if box i cannot be placed directly on top of box j. This relation is not necessarily transitive and may be symmetric. In our mathematical model, parameter g_{ij} is equal to 1 if arc (i, j) belongs to graph G and zero otherwise.

We illustrate the concept of graph G in Fig. 2. Arc (2, 3) indicates, e.g., that box 2 cannot be placed on top of box 3. Thus, the boxes cannot be packed as shown in the left scheme.

We define the variables $\gamma_{ij} = 1$ if boxes i and j are in the container, $c_{zi} > c_{zj}$ and $c_{zi} - c_{zj} - \frac{1}{2}\sum_{\alpha\in\{l,w,h\}}(d_{\alpha i}\delta_{\alpha z i} + d_{\alpha j}\delta_{\alpha z j}) = 0$ and zero otherwise, $i \neq j$.

Let us first ensure that if both boxes i and j are packed then $\gamma_{ij} = 1$:

$$\gamma_{ij} \geq \chi_i + \chi_j - 1, i \neq j \tag{11}$$

and that if any of the boxes i, j are not packed then $\gamma_{ij} = 0$:

$$2 * \gamma_{ij} \leq \chi_i + \chi_j, i \neq j \tag{12}$$

The following equation shows that if $\gamma_{ij} = 1$ then the distance between the coordinates of boxes i and j along axis z (the vertical one) allows that box i is exactly on top of box j.

$$\gamma_{ij}\left[c_{zi} - c_{zj} - \frac{1}{2}\sum_{\alpha\in\{l,w,h\}}(d_{\alpha i}\delta_{\alpha z i} + d_{\alpha j}\delta_{\alpha z j})\right] = 0 \tag{13}$$

Finally, we formulate the condition (14) making sure that if γ_{ij} =1 and g_{ij} =1 (box i cannot be placed on top of box j) then the boxes do not intersect along at least one axis X or Y.

$$\sigma^{+}_{xij} + \sigma^{-}_{xij} + \sigma^{+}_{yij} + \sigma^{-}_{yij} \geq g_{ij}\gamma_{ij} \tag{14}$$

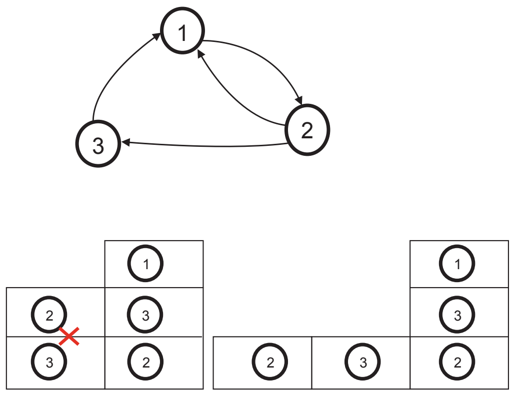

Fig. 2. Part dependency graph and the example solution

1.2.4. Load stability constraints

Load stability constraints are a combination of spatial and mass constraints. The main idea is to allocate the boxes in such a way that they do not fall not only in a static position but also while the container is being moved. The most challenging situations occur when it is being turned and lifted or when the vehicle carrying the container speeds up or slows down rapidly.

Bischoff and Ratcliff (1995) propose a heuristic solution that produces patterns which combine efficient space utilisation with a high degree of stability. The algorithm generating stable loads is based on earlier work by Bischoff (1991) on stability aspects of pallet loading. Quite an efficient algorithm combining a construction heuristic with a search algorithm for the problem with limited load bearing strength of boxes was proposed by Bischoff (2006).

For three-dimensional problems Fasano (2004; 2008) expressed the requirement that the overall centre of gravity of a container must stay within a given convex domain. Also, for three-dimensional problems Takadama et al. (2004) and Egeblad (2009) cope with this balancing requirement in combination with the objective function. Egeblad additionally includes inertia moment characteristics of the loaded container. De Castro et al. (2003) and Junqueira et al. (2012) look upon stability, bearing and dropping constraints too.

Amiouny et al. (1992), and Mathur (1998) considered a slightly different problem called "balanced loading" where the goal is to generate a pattern for which the centre of gravity is as close to a predefined point as possible. The motivation for such a goal comes from aircraft loading. Both papers present heuristics for a one-dimensional problem.

We assume that the load is stable if the gravity is compensated by the support of another box or the container floor. We calculate the stability using the centre of mass of a box allocated over another one. We also assume that the centre of mass coincides with the geometrical centre of the box which is acceptable in most practical situations.

We introduce variables $\lambda_{ij} = 1$, $i \neq j$ if boxes i and j are packed and box j supports box i and zero otherwise. Moreover, we assume that $\lambda_{i0} = 1$ if i is packed and placed on the floor of the container and zero otherwise.

Constraint (15) ensures that if the distance between the centres of box i and j in the vertical axis is not exactly equal to the half-size of the corresponding sides then box j may not support box i (and vice versa). It also ensures that $\lambda_{ij} = 0$ if any of the boxes i or j are not packed.

$$\lambda_{ij} \leq \gamma_{ij}, i, j \in \{1, \ldots, n\}, i \neq j \tag{15}$$

The next equation ensures that box i may be placed on the floor only if box i is packed in the container:

$$\lambda_{i0} \leq \chi_i, i = 1, \ldots, n \tag{16}$$

Inequalities (17) and (18) hold if in case j supports i, the projection of the centre of mass of box i on the plane (X, Y) fits inside the rectangle being the projection of box j.

$$\lambda_{ij} \left[c_{xi} - c_{xj} - \frac{1}{2} \sum_{\alpha \in \{l,w,h\}} d_{\alpha j} \delta_{\alpha x j} \right] \leq 0, i, j \in \{1, \ldots, n\}, i \neq j \tag{17}$$

$$\lambda_{ij} \left[c_{yi} - c_{yj} - \frac{1}{2} \sum_{\alpha \in \{l,w,h\}} d_{\alpha j} \delta_{\alpha y j} \right] \leq 0, i, j \in \{1, \ldots, n\}, i \neq j \tag{18}$$

Equation (19) states that for the boxes located on the floor of the container the coordinate of the centre of mass along axis z is exactly one half of the length of the corresponding side of the box.

$$\lambda_{i0} \left(c_{zi} - \frac{1}{2} \sum_{\alpha \in \{l,w,h\}} d_{\alpha i} \delta_{\alpha z i} \right) = 0, i = 1, \ldots, n \tag{19}$$

Finally, equation (20) guarantees that each box is either packed on the floor or is supported by another box.

$$\sum_{j=0, j \neq i}^{n} \lambda_{ij} \geq 1, i = 1, \ldots, n \tag{20}$$

The heuristic algorithm presented in Section 2 also takes into account the stability constraints.

1.2.5. Other constraints

Other constraints may follow from the organisational reasons, for example, when the load has many destinations, and some items have to be unloaded earlier and others later at another destination. Then, it is convenient to allocate the items according to the unloading order.

Bischoff and Ratcliff (1995) proposed a heuristic that considered the multi-drop situation and constructs a pattern with distinct sections across the width of the container which correspond to the different destinations.

We propose to model these constraints by dividing the space of the container into "subcontainers" corresponding to consecutive drops and pack each subcontainer separately.

2. Solution method

2.1. Related work

The first and somewhat sophisticated heuristics for the container packing problem was proposed by George and Robinson (1980). It was a wall-building procedure that was later improved and verified for various ranking rules by Bischoff and Mariott (1990). Also, Pisinger (2002) constructed an algorithm using the concept of wallbuilding. His heuristic decomposes the problem into some layers which again are split into some strips. The packing of a strip may be formulated and solved optimally as a Knapsack Problem with a capacity equal to the width or height of the container. The depth of a layer as well as the thickness of each strip is decided through a branch-and-bound approach where at each node only a subset of branches is explored. Eley (2002) proposed an algorithm being a combination of a greedy heuristic generating blocks of boxes with a tree search procedure. Another approach using a slightly modified concept of wall building with a greedy randomised adaptive search procedure (GRASP) was examined by Moura and Oliveira (2005) and Parreno et al. (2010).

Other approaches are presented in the literature where one can find a 3D-BPP problem in Sciomachen (2007) (items are containers, and the bins are ships). Also, in Terno et al. (2000) the multi-palleting 3D loading problem with the minimal number of pallets is considered.

Several metaheuristic approaches to solving the container packing problem have been proposed as well starting with the genetic algorithm by Gehring and Bortfeldt (1997). In their further works, the same authors developed a tabu search algorithm (Bortfeldt & Gehring, 1998), a hybrid genetic algorithm (Bortfeldt & Gehring, 2001) and a parallel genetic algorithm (Gehring & Bortfeldt, 2002). A parallel tabu search algorithm (Bortfeldt et al., 2003) and a hybrid local search algorithm combining simulated annealing and tabu search (Mack et al., 2004) were developed in continuation of the earlier research.

2.2. Algorithm

Numerous heuristic approaches have been proposed in the literature to solve the basic container loading problem. Only a few of them consider additional constraints described in Section 1. We propose the best fit heuristic based on the idea of wall building that in addition to volumetric and mass constraints considers layer and load stability constraints. In particular, the following constraints are implemented:

- orientation of selected boxes may be arbitrarily fixed,
- layer constraints described in Section 1.2.3 may be defined by a corresponding directed graph,
- load stability constraints described in Section 1.2.4 are respected.

Basically, the packing scheme follows the wall-building idea by George and Robinson (1980). The container is packed layer by layer, where a layer is defined as a section of the container length over its total width and height. The length of a layer is defined by the first box packed in this layer. No new layer may be initiated unless the previous layer is completed.

We define *available space* as a parallelepiped inside the container with sides parallel to the sides of the container and neither intersecting nor containing any box. An available space S^i_j may be divided by a new box i+1 as shown in Fig. 3. This operation results in removing the available space S^i_j, adding box i+1 to the container and constructing a set of available spaces $S^{i+1}_{j1}, \ldots, S^{i+1}_{jk}$ so that:

(a) $S^{i+1}_{jl} \subseteq S^i_j, l = 1, \ldots, k$,

(b) S^{i+1}_{jl} is disjoint with box i+1, $l = 1, \ldots, k$,

(c) $\bigcup_{l=1}^{k} S^{i+1}_{jl}$ has maximum volume of all sets that fulfil (a) and (b).

To decrease the running time of the algorithm, if available space, is a subset of another available space it is removed from further consideration.

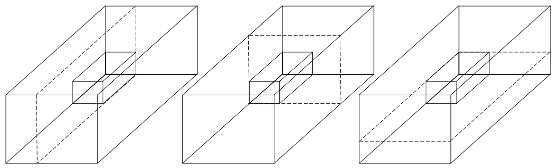

Fig. 3. Available spaces resulting from packing a box

Let us observe that if no orientation constraints exit, six different orientations of a box are possible as shown in Fig. 4.

The heuristic tries to pack a box in every feasible orientation until it fits into available space. If no such space exists for any orientation, the box is rejected. It is easy to notice that the order in which possible orientations are checked may influence the solution. Since we have six possible orientations at the most, there exist only 6! = 720 such orders (permutations). We run the heuristics for each permutation.

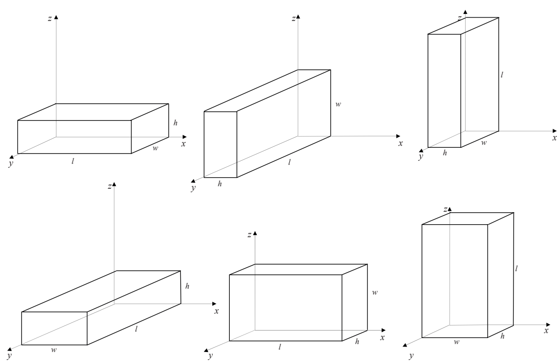

Fig. 4. Different box orientations

Thus, in a given run of the algorithm, the order in which box orientations are checked is fixed. Boxes are considered in the non-increasing order of their volume. If there is no available space where the box may be packed in a given orientation, then the next orientation is selected. If a box cannot be packed in any orientation, it is rejected together with all boxes of the same type. Then, the next box is selected. After considering all boxes, the next run of the algorithm starts with a new permutation of box orientations. The best solution of all 720 runs is selected.

A more formal description of the algorithm is presented in Section 2.3.

2.3. The Best-Fit algorithm

For every possible permutation of box orientations do:

1. Add the initially available space corresponding to the whole container to the set of available spaces.
2. Select the largest box not yet considered. If there are no boxes to be packed, go to step 5.
3. For every orientation from the current permutation do:
   a) select the smallest yet unchecked available space and try to pack the current box there,
   b) if all constraints are met, then:
      - pack that box respecting its current orientation,
      - divide all available spaces intersecting with the selected box and add the new available spaces to the set of available spaces,
      - remove each available space that is included in another available space,
      - go to step (2).
   c) if there are still unchecked spaces, go to step (3a).
4. Reject the selected item and all items of its type. Go to step 2.
5. If the current solution is better than all of the solutions found so far, then remember it.
6. Remove the current solution.

If no box has been rejected then all boxes are packed; otherwise, there are some unpacked boxes left. Step 4 is not required to obtain a feasible solution; however, it decreases the complexity of the algorithm. Otherwise, the number of available spaces grows very fast.

Obviously, more complicated orientation requirements may be defined by the user. For example, additional space required for manoeuvring of the loading vehicles (forklifts or pallet trucks) may be required. This additional space obviously decreases the container volume available for packing the boxes thus affecting the value of the objective function. Moreover, the location of the door may influence the order of packing and in consequence the location of some items. Such constraints may be considered by the proposed heuristics by defining the available space appropriately.

3. Computational experiments

3.1. Test-bed

The algorithm was implemented in Java, and the tests were run on a computer with Intel Core 2

Quad CPU Q9650 with 3.00GHz, 8GB of core memory and OpenSuSE Linux as a single-threaded application with 120 seconds of processing time.

The set of test instances most often used in the literature was proposed by Bischoff and Ratcliff (1995). In this set, however, no additional constraints like orientation, load stability or layers constraints were defined. Nevertheless, our first experiments were performed on this set of instances with 3, 5, 8, 10, 12, 15 and 20 boxes. The results were on average no more than 9% worse in terms of the volume utilisation as compared to the algorithms by Bischoff and Ratcliff (1995); Bischoff (2006); Lim et al. (2005). Only the GRASP algorithm by Parreno et al. (2010) showed significant advantage (more than 10% on average) but at the expense of longer computation. These results were promising enough to continue the experiments on instances with additional constraints. Although we cannot compare our algorithm with other algorithms, the obtained results have been assessed by practitioners as highly satisfactory in a real setting. There is also a natural upper bound of volume utilisation which is 100% because it follows directly from the problem formulation, so the user has quite precise information about the quality of the solution even without knowing the optimal solution.

Although the motivation for our model comes from a practical application, unfortunately, no real order test instances are available. To evaluate the algorithm performance, we have prepared a set of instances based on a list of real products. The real data include box size, mass and the possible box orientation. The list contains 99 types of products. An instance is constructed by randomly choosing boxes from the list to set up a shipment order.

The experiment was performed on a set of 720 instances where ten instances were randomly generated from each of 72 groups. The groups of instances were defined by providing:

- container size (3),
- number of box types (4),
- number of pivot points (2),
- volume ratio (3).

The total number of combinations of the above parameters gives 72 instance groups.

The first typical container size was assumed to be 2.4 m wide, 2.6 m high and 12.2 m long. Two other types were two and three times shorter, respectively.

The number of different box types is assumed to be 2, 5, 10 or 20 chosen from the list of 99 different box types. The following algorithm was proposed to select box types constituting an instance:

- order all box types by non-decreasing volume,
- define a range of items as items at most p positions from a pivot value point,
- select box types evenly from the defined range.

There could be one or two randomly chosen pivot value points. We assumed $p = 0.3$ for a single point and $p = 0.5$ in case of two preference points (Fig. 5).

Finally, the number of boxes of each type is decided as follows. In each instance, a group of "smaller" and "bigger" boxes are distinguished based on the volume of the selected box types. Depending on the number of box types in an instance we have:

- two box types: two groups of one item each,
- five box types: the first group of two items, the second group of three items,

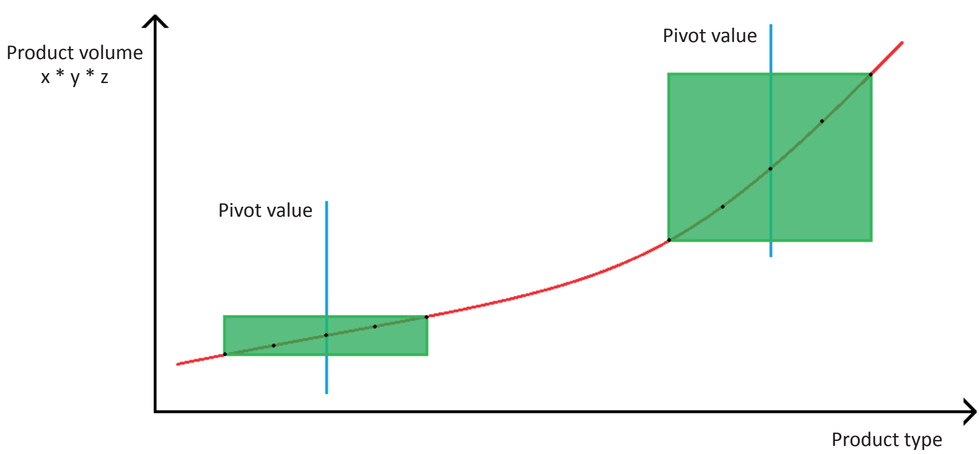

Fig. 5. Generating box size of the volume distribution for two pivot values

- ten box types: two groups of five items each,
- twenty box types: two groups of ten items each.

The total volume of all boxes in an instance is a random number between 110% and 150% of the container capacity volume. Next, generated boxes are divided into two groups. The volume ratio (50%–50%; 20%–80% – more items from the second group; and 80%–20% – more items from the first group), allows to calculate the approximate total volume of items, from the first and second group, respectively. Finally, for each box type in the group, the number of items is obtained from a uniform distribution so that the total volume of the group is reached.

Eventually, for every instance, the graph of layer constraints (Fig. 2) is randomly generated.

3.2. Results

The computational results are summarised in Tab. 1. The quality of the solution and computational execution time for different container capacity, from *C*1 to *C*3 and different type of boxes, from 2 to 20, are presented in Fig. 6 and Fig. 7. The main entries in Tab. 1 give the usage of container capacity in percentage.

The algorithm presented in the previous section is tested on a set of instances representing the data for the real products and the real size of the containers. It was also necessary to test algorithms for the smaller containers to reflect the situation where a container is divided into two or three spaces because the product is delivered to two or three different customers.

We obtain comparative results through implementation of our MIP model in CPLEX 12.3. CPLEX solves only the very simple and unrealistic instances of several boxes in the time of 2 minutes. No instance from the listing (Tab. 1) could be solved within a 10 hours time limit, and our MIP-based approach was not competitive and useful in the practical case.

In Fig. 6, the percentage distance (in volume usage) from the potentially possible 100% solution is shown. One can observe that the solutions of capacity usage delivered by the algorithm depend on the number of different types of boxes. For example, for two types of boxes, the simplest case, the utilisation of available volume space in the container is more 90%, on average. The value of the results decreases when the number of types of boxes increases. In the practical situations, two to five types of boxes are packed on the truck.

For these cases, the average usage of capacity is over 80% which is a generally expected result in practice. However, in particular cases, the space usage in the truck could be much lower, especially when the dependency graph is very restricted, for example in the case, where only one layer of the product is allowed.

Fig. 7 depicts execution times over all original instances. The plots in the Fig. 7 show minimum, first, second, third quartile, and maximum execution times. There is an upper limit of 120 seconds of the execution time. The execution time of such kind of algorithms naturally depends on the container size

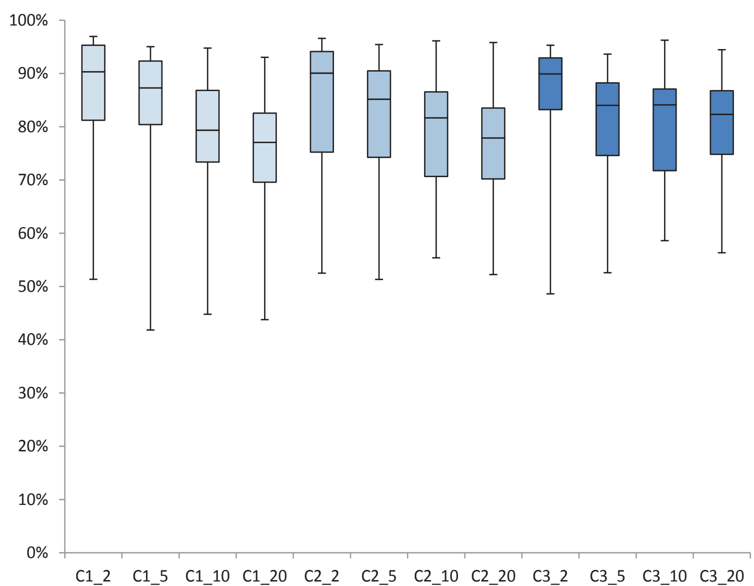

Fig. 6. Volume usage for three sizes of containers and different numbers of box types

Tab. 1. Results for three different container sizes

	Ratio	Pivot value	Number of types			
			2	5	10	20
Container 1 (40 ft)	50/50	1	82.04	82.24	72.47	76.01
		2	92.92	92.40	80.22	78.92
	20/80	1	80.39	80.78	83.07	69.92
		2	96.54	92.16	81.86	83.55
	80/20	1	77.67	71.13	73.50	65.48
		2	90.17	85.50	76.73	81.02
	Ratio	Pivot value	Number of types			
			2	5	10	20
Container 2 (20 ft)	50/50	1	80.86	73.40	76.84	74.08
		2	94.10	87.27	80.00	76.47
	20/80	1	83.40	80.93	74.47	78.73
		2	96.60	86.91	81.97	81.53
	80/20	1	69.95	71.00	74.23	68.19
		2	79.46	84.30	82.83	82.04
	Ratio	Pivot value	Number of types			
			2	5	10	20
Container 3 (13 ft)	50/50	1	80.28	79.34	76.08	81.82
		2	91.49	88.50	85.58	78.19
	20/80	1	79.14	73.12	85.49	77.62
		2	93.55	85.06	83.03	83.35
	80/20	1	76.35	73.93	75.07	77.63
		2	86.34	87.03	76.64	82.01

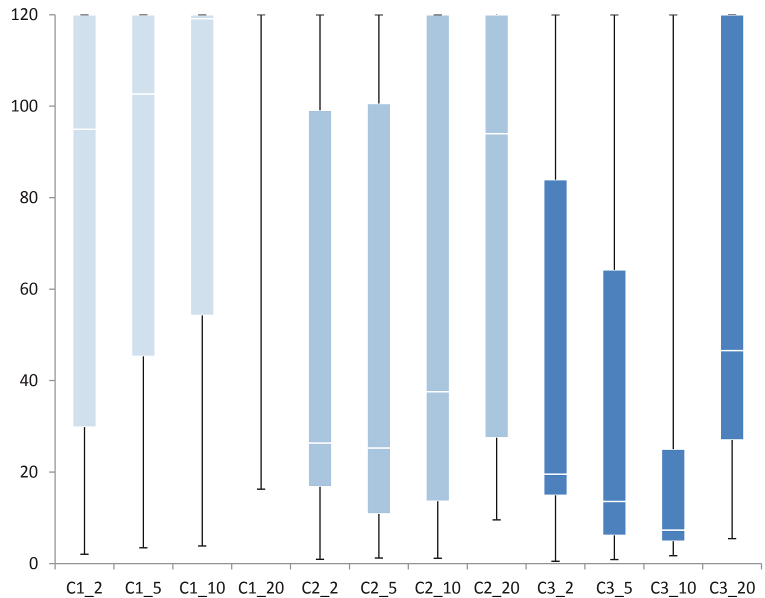

Fig. 7. Execution time of the algorithm for three sizes of containers and different numbers of box types

and the number of types of boxes, which is depicted in Fig. 7.

Overall, it can be concluded that the heuristic provides an 80% capacity usage solution within the imposed execution time. This result is satisfactory from the application of the methods point of view.

Conclusions

In this paper, we propose a MIP model and the solution of a 3D packing problem. Though this problem has similarities with other well known OR and packing problems, it is fundamentally different because we consider a real shipment environment and a part of a real application is in the focus of our solution approach. Generally, this problem is computationally hard, but the results obtained by a heuristic proved to be practically "good enough" to generate packings that have been highly appreciated by the company.

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Urban smart mobility in the scientific literature — bibliometric analysis

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ABSTRACT

This article aims at identification of the main trends in scientific literature characterising urban smart mobility, on the basis of bibliometric analysis of articles published in the ISI Web of Science and Scopus databases. The study period was set from 2000 to 2017. Authors used a basic technique of the bibliometric analysis of the scientific literature characterising urban smart mobility with the support of the VOSviewer software. The analysis included the number of publications, citation analysis, research area analysis and the most frequent keywords. The analysis led to taking notice of current research trends dealing with the urban smart mobility. The core of the paper is a theoretical framework of research trends, which was developed through a review of scientific literature. The result of this paper is a map showing the existing relationships between key terms, research areas characterising publications dealing with the urban smart mobility and intelligent transport system (ITS). "Smart city" is probably the most "in vogue", debated and analysed concept among researchers and administrative/governmental representatives from all over the world. This multidimensional concept is mainly based on smart technology structured around few major components: smart mobility, smart environment, smart governance, smart living, and everything that targets the people's wellbeing. This work focuses on a hot topic – mobility because of its significant impact on the environment by pollution as well as living by requiring intelligent transport systems.

KEY WORDS

smart mobility, bibliometric analysis, urban intelligent transport system, urban mobility

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Introduction

This paper tackles an important issue of modern cities, namely, smart mobility, presenting the main challenges and possible solutions as well as the stakeholders involved and responsible for applying these. It presents the developed bibliometric analysis of scientific publications dedicated to smart mobility and presents advantages for different communities: scientific researchers and academia, municipalities and companies.

Contemporary cities must be able to deal with the effects of progressing globalisation trends, processes of integration and urbanisation. The industrial evolution has both benefits (increasing wellbeing) and drawbacks (city crowding). The level of welfare of many families can be measured by the number of owned cars; in many cases, the number more than one. But this means much more traffic which includes the public and heavy goods transport, creating congestion and, finally, air and noise pollution. Also, parking space and other infrastructure problems are the consequence of city crowding. Furthermore, the lack of road infrastructure determines the increasing number of injuries and accidents which reflect in medical costs and economics (Welle et al., 2018).

Since smart mobility is part of the multidimensional concept of a smart city, solutions have to come from multiple directions: municipalities, scientific researchers, environment agencies, transport companies, etc. (Ejdys, Nazarko, Nazarko & Halicka, 2015). Local authorities are becoming increasingly interested in intelligent solutions which help them build the city's competitive advantage and, in effect, attract human capital, business and investors. It should be noted that the number of local governments utilising Intelligent Transport Systems has grown in recent years.

The contribution of our work targets both the scientific community and companies as well as municipalities. For scientific researchers, our bibliometric study will emphasise challenges, solutions and weaknesses, helping them to find science networks working in the smart mobility field for the identification of further potential research partners. Companies will benefit recognising technological trends and global market evolution, of competitor activities, and may forward their in-house research and development activities. The municipalities or funding organisations may use this work to make regional, national or international comparisons of practical solutions regarding intelligent transport systems or to set the timeframe for their implementation.

This paper focuses on publications in the form of scientific articles on urban mobility and intelligent transport systems, which have become an area of discussion and scientific research in recent years. This article aims to make a bibliometric analysis of international literature, namely, scientific articles published in the Web of Science and Scopus databases in years 2000–2017, to identify and take a closer look at current research trends related to the concept of urban smart mobility. The study uses basic techniques of the bibliometric method with the help of the VOSviewer software. In this article, authors identify the main research areas in the literature and propose future research streams in the analysed context.

The structure of the paper is as follows. Sections 1 and 2 describe definitions, challenges and possible solutions regarding the smart mobility. Section 3 presents an overview of the bibliometric methodology, whereas Section 4 illustrates the research results. Finally, the last part concludes the paper and suggests some directions for future work.

1. Literature review

There is extensive literature that describes the basic concepts and assumptions related to smart cities. A smart city has many definitions, but it is also rather frequently identified with such terms as a "digital city", "intelligent city", "creative city" or even a "smart community".

Cities around the world have built a transformative culture around six components characterising a smart city: smart governance, smart mobility, smart environment, smart economy, smart living and smart people. A smart city is often defined as an urban space with complete and advanced infrastructure, intelligent networks and platforms, with millions of sensors used by people and their mobile devices (Yue, Chye & Hoy, 2017). Neirotti et al. (2014) defined a smart city "as an ecosystem that is largely developed through the effective use of technology with the aim of improving the quality of life of citizens achieved through efficient integrated systems and services." A smart city is often defined in the literature as a well performing and forward-looking city described using six characteristics, namely, economy, people, governments, mobility, environment and life, and based on the intelligent combination of capital and the activity of self-decisive, independent and aware residents. Furthermore, a smart city searches for intelligent solutions that help improve the quality of services provided to citizens and identifies those (Romanowski & Lewicki, 2017). A smart city is furthermore used to discuss the use of modern technology in everyday urban life, which besides ICT, includes especially modern transport technologies (Giffinger et al., 2007, p. 10).

Nowadays cities are constantly changing, and new technologies are one of the main factors that led to the emergence of smart cities. There are many examples of smart cities and ideas that fit into the intelligent solutions, which may concern (among other improvements) the transport infrastructure (Romanowski & Lewicki, 2017). Within the current economic period which will last until 2020, the transport infrastructure has become especially challenging in respect to city development and the processes of urbanisation.

In the literature, smart mobility is often presented as one of the main options for more sustainable transport systems (Pinna, Masala & Garau, 2017). Benevolo et al. (2016) state that smart mobility could be perceived as "a set of coordinated actions addressed at improving the efficiency, the effectiveness and the environmental sustainability of cities." The main aspect of smart mobility is connectivity, which along with big data, allows users to transmit all the traffic information in real time while representatives of local governments of cities can simultaneously conduct dynamic management (Pinna, Masala & Garau, 2017). In other words, urban mobility is mostly related to traffic management in real-time, management of passenger transport means, tracking applications and logistics, car park management and car sharing services, and another various smart mobility services (Yue, Chye & Hoy, 2017).

Scientific research conducted in the past confirm that the intelligent transport system supports urban smart mobility (Mangiaracina, 2017; Papa, Gargiulo & Russo, 2017; Battarra, Zucaro & Tremiterra, 2017). An intelligent transport system (ITS) means the advanced mode of transportation systems that include many pieces of software, which are helpful for safe transportation, diminish traffic congestion, reduce air pollution, increase energy efficiency and promote the development of the associated industries (Chandra, Harun & Reshma, 2017). According to Directive 2010/40/EU, intelligent transport systems "integrate telecommunications, electronics and information technologies with transport engineering to plan, design, operate, maintain and manage transport systems". Intelligent transport systems encompassing modern technological and organisational transport solutions enable, among other things, traffic control, the creation of special zones of limited access and low CO2 emissions by limiting the number of private cars in city centres. ITSs aim to increase the safety of traffic participants and to improve the effectiveness of the transport system as well as to protect the natural environment. They undoubtedly comprise the most effective instruments for the improvement of city transport system's effectiveness and quality (Ministry of Transport…, 2013). In other words, ITSs are advanced applications which enable various users to be better informed and make safer, more coordinated, "smarter" use of transport networks (Directive 2010/40/EU).

2. Main concepts, challenges, and practical solutions of smart mobility

Smart mobility supposes developing logistic and transport activities using digital smart technologies, the mandatory existence of online databases, traffic optimisation and aims to reduce the negative effects of mobility (especially pollution) and optimise resource consumption. The transport system (public and private), as well as heavy goods transport, represent the support system for mobility services, which are vital for the city and citizens (Czech et al., 2018). Public transportation management must help the municipality to make the public transportation easier to use and more reliable, and at the same time help the operations optimisation with the new embedded digital features, such as issuing tickets and traffic lights synchronisation for traffic decongestion, increasing the efficiency, the safety and the coordination between different transport networks from the city. The benefits of such efficient management would be:

- real-time information about the public transportation,
- more efficient administration of the public transportation,
- possibility for citizens to access the information system online via smartphones,
- even greenlighting the traffic lights on request.

2.1. Challenges regarding smart mobility

The inefficient modes of transport, data centres and industrial activities represent important sources of air pollution. In this millennium, the transportation became the major source of carbon emissions worldwide. More than a quarter of these CO2 emissions are due to transportation, and the road transport contributes around 65% of it (Turkensteen, 2017). Wrong political decisions which enable reducing taxes on importing second-hand cars contribute to increasing pollution levels. For example, such measure resulted in the increase of the number of second-hand registered vehicles in Romania amounting to over 71% in 2017 compared with the previous year. In 2016, the European Environment Agency identified transport as the single biggest GHG emitter (Lewald, 2017).

An intelligent transport system and traffic streamlining represent key factors to success in attracting business investors to a developing country. On the other side, the life quality of citizens, personal and business productivity can decrease as a consequence of traffic congestion. Furthermore, the rate of accidents and noise pollution increases, diminishing the air quality.

Accelerated industrial development has led to population growth in certain cities, the development of existing cities and the emergence of new ones, the creation of large industrial complexes that attract the workforce from villages or even from other cities. This growth determined the consumption of additional resources and generated more social problems (waste, pollution, health). Statistics indicate that more than 51 percent of the world's population from developing countries and 80 percent in those in the developed ones will live in cities in 2020 (Dirk & Keeling, 2009), and this number is forecasted to still rise in the coming years. Unfortunately, the increase of urban areas has not doubled by the development of the existing infrastructure, both of the transport and the urban utilities.

A very recent study developed by the World Resources Institute (WRI) and the World Bank suggested that governments should treat road accidents as a public health problem. Yearly, there are 1.25 million road accidents that lead to death due to the lack of road and pavement networks, inappropriate urban development, inadequate laws or their poor enforcement. Injuries and deaths caused by road accidents have a high economic impact. For example, the same report highlighted that 82 developing countries pay around $220 billion a year in the form of medical expenses and productivity losses. Consequently, there is more important to provide prevention actions by improving public transport systems, smart mobility solutions in and outside cities to reduce accidents and road deaths affecting developing countries (Welle et al., 2018).

2.2. Possible solutions

An example of implemented smart mobility is an urban traffic management system connected to a public transportation management system and an information management system about urban travels (including the priority for public transportation in crossroads). The system can be connected to an air quality monitoring system that allows the implementation of some regulatory measures targeting pollution during traffic jams (smart environment). Changing routes with heavy traffic and reducing pollution in inhabited areas increases the life quality of citizens and rehabilitates pedestrian routes in the urban transport network, making the city friendlier to its inhabitants (smart living).

The future ideas regarding a smart city aim first at making mobility smarter and cleaner (Lewald, 2017). One important measure to reduce air pollution is to reduce car traffic by mostly using public transport instead of private cars. An intelligent public transport infrastructure must target the reduction of traffic load. People must be (re-)educated with civic skills, and authorities must use gamification mechanisms which reward responsible behaviour and punish the wrong attitude. Awareness about environment changes can be boosted by incentives to change behaviours. The promotion must focus on the idea that efficient mobility does not require vehicle ownership. Car owners may also be discouraged by toll charges or congestion charges implemented in many cities. A strategic lever to control congestion might be the use of parking charges, congestion time pricing for downtown parking areas, park-and-ride location along the metro, tram or rail line, which could have a positive impact on the utilisation of the public transport. An interesting and functional example is Shanghai Uber for bike system (van Mead, 2017). Combining the use of metro with bike-sharing from home to office and back could be a solution for replacing the travel to work with own cars, also considering that cars remain parked 95% of the time (Florea & Berntzen, 2017).

Smart public transport uses the technology to provides public transport users with a better user experience. The use of sensors and the GPS (Global Positioning System) technology can provide real-time data on arrivals and departures of public transport. Smart ticketing solutions may use smart cards or mobile phones to make ticketing more efficient from a user's point of view (Florea & Berntzen, 2017). Online route planners which may provide much more useful information beside the travelled distance and crowded zones, such as air quality, road profile, profit might be obtained on each route, may help users choose the most efficient route from one location to another.

A city's intelligent traffic management must mitigate congestion and use all available information, even provided by citizen participation, as a foundation for planning a multimodal transport system including its predictive operational control. The data

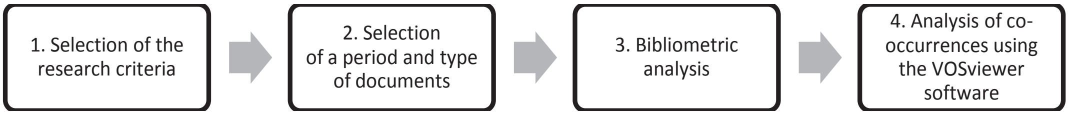

Fig. 1. Methodology of research

collected from smart public transport can be used for real-time situation reports and may also be used by public transport planners to adjust timetables, increase the number of buses at rush hours, change routes, create new routes, and adjust fares. Social media may be mined to find citizen perceptions regarding a public transport system. The important challenge is "how can we get more people to travel by public transport, in a region where most people prefer to travel by car?" (Johannessen & Berntzen, 2016). However, it must be kept at an equilibrium between business goals for improving the quality of life, maintaining the city's sustainability development, and the social participation and responsibility.

Since reducing the number of cars is very difficult to be accomplished, the effort for keeping a clean environment must be supported by industrial companies, especially automobile manufacturers, who need to develop low-emission mobility strategies (Lewald, 2017). The polluting emission minimisation policy should be implemented through the production of new vehicles and engines, including electric cars, and applied to existing cars. For example, Volvo will stop developing the new generation diesel engines and will focus on electric vehicles (Caughill, 2017). Other companies develop new particulate filters that are very effective in cutting emissions from existing diesel cars.

Typical IT solutions aiming to improve air quality and make mobility smarter and cleaner are:

- developing new heuristic algorithms to measure, evaluate and minimise CO2, NOx, and CO emissions in multi-depot Green Vehicle Routing problems (Turkensteen, 2017) with economic and social applicability;
- applying machine learning algorithms in solving Ridesharing problems to reduce vehicle emissions, maintaining too of decent living standards through development of infrastructure and qualitative services (Jalali et al., 2017);
- developing Breath Journey software applications that combine GPS track with air quality for travel planning which can show the distance information, data regarding the pollution levels on the respective routes. Thus, the programming paradigm will change from Software as a Service (SaaS) to Mobility as a Service (MaaS), providing very accurate, real-time, customised, wireless mobility information services regarding travel planning, journey time, air quality, online booking and payment facilities (Florea & Berntzen, 2017).

3. Research methodology

To achieve the aim of the article, the authors conducted a bibliometric analysis of scientific articles. Fig. 1 presents the methodology stages.

The methodology involved the following four stages:

1. Selection of the research criteria:
   - scientific articles listed in the Web of Science database referringto "urban smart mobility" or "urban intelligent transport system" in their topic;
   - scientific articles listed in the Scopus database referring to "urban smart mobility" or "urban intelligent transport system" in titles, keywords or abstracts.
2. Selection of a period and type of documents:
   - scientific articles published between 2000 and 2017.
3. Bibliometric analysis:
   - analysis of 610 articles published in the Web of Science database, and 524 papers listed in the Scopus database;
   - the analysis included: the number of publications in the analysed period, the citation analysis, research/subject area analysis of articles published in both databases and the most frequent keywords in articles listed in the Scopus database.
4. Co-occurrences analysis:
   - an analysis of the occurrence of key terms indicated by authors in the Scopus database and analysis of a map of current research trends, which shows the existing relationships between those keywords.

Within the last stage of the analysis, the authors prepared a map with the VOSviewer software (a tool for constructing and visualising bibliometric networks), which used advanced layout and clustering techniques to show the existing relationships between keywords characterising articles from the Scopus database. The program highlighted the frequency and co-occurrence of keywords that appeared in the network (Siderska & Jadaan, 2018). The program also combined the analysed set of data into clusters, using the state-of-the-art techniques for the network layout and providing network clustering (van Eck & Waltman, 2017; Glińska & Siemieniako, 2018). It has allowed identifying the main areas of research in urban smart mobility.

4. Research results

The concept of a smart city, especially smart mobility and intelligent transport systems have become very popular in recent years. To analyse the current research trends among publications dealing with urban smart mobility or an intelligent transport system (ITS), the authors started with verifying the number of publications available in the Web of Science and Scopus databases (Fig. 2). The authors carried out the analysis of the number of publications after the year 2000, when the number of publications exceeded seven in the Scopus and two in WoS databases.

The number of articles published in 2000–2017 that included references to the concept of urban smart mobility or ITS was 610 in the case of WoS database and 524 in the Scopus database. Analysing the number of works in each subsequent year, one can first notice a mild increase in the interest in this subject after 2006 and a significant one after 2014. It should be noted that the popularity of publications dealing with urban smart mobility indexed in both databases is currently characterised by an upward trend or journals probably did not finish the indexing process). Since 2015, the number of publications in the analysed context exceeded 100 works per year in the WoS database.

Fig. 3 presents the most popular research area of articles indexed in the Web of Science database (the size of the font used in the illustrations below reflects the number of papers from a particular area). The research areas which exceeded 200 papers referring to the analysed concept were "Computer Science" and "Engineering". The research area showing over one hundred articles was "Transportation". Other mainly represented areas were: "Telecommunications", "Urban Studies", "Environmental Sciences Ecology", "Science Technology Other Topics" and "Business Economics". In the Web of Science database, it was also possible to identify the most popular WoS categories of published articles. According to our analysis two main WoS categories, which include more than 100 articles, were: "Engineering Electrical Electronic" and "Transportation Science Technology".

In contrast, all the identified articles in the Scopus database mainly represented three subject areas: "Engineering" (290), "Social Sciences" (211) and "Computer Science" (210). The number of publications in the areas "Mathematics" and "Environmental Science" exceeded 50 papers (Fig. 4). It should be noted that WoS and Scopus databases differ in scope, data volume, coverage with unique sources and articles. Moreover, each database is characterised by different names of research/subject area. However, as part of this bibliometric analysis, both databases consider the engineering and computer science perspective in the research area involving urban smart mobility and also refer to business. Some of the analysed publications pertain to the research area "Business economics" in the Web of Science database and the subject area of "Business, Management and Accounting" in the Scopus database. The analysis of the research/subject areas of articles listed in both databases, lead to the observation of similar trends. These results are in line with our statements from the beginning of Section 1, where we have shown that Computer Science creates the tools considering the future plans for Transportation with large applicability for Business companies and Municipality, under the environmental regulations and for the well-being of citizens.

To take a closer perspective of the contemporary research trends dealing with urban smart mobility, the authors analysed five the most cited publications available through the Web of Science and Scopus databases (Tab. 1).

Papers have been thoroughly analysed by authors of this article, and they are mainly focused on current trends in smart cities and innovation of technology. Top three most cited articles are the same in both databases, but a higher number of citations refers to the Scopus database. Judging by a publication's title and sources but also analysing the abstract of these most cited papers, we appreciate that Tab. 1 is in line

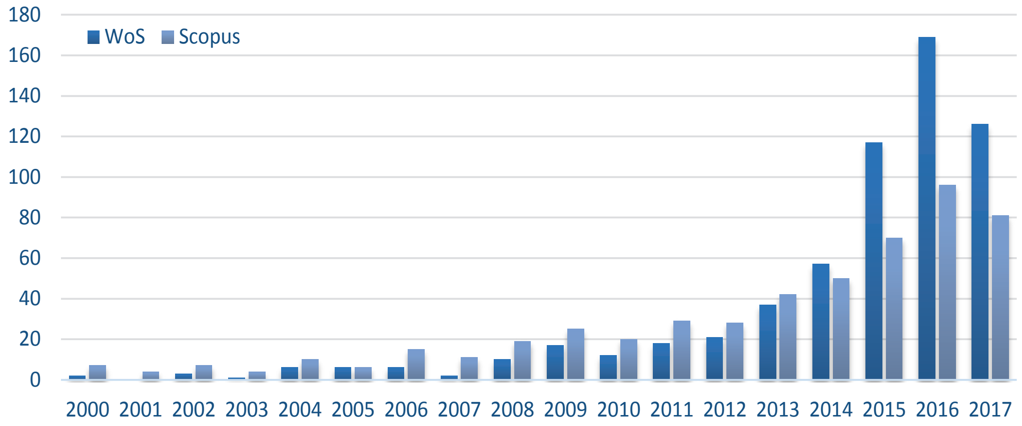

Fig. 2. Number of publications indexed in the Web of Science (WoS) and Scopus databases referring to the concept of urban smart mobility and ITS between 2000 and 2017

Fig. 3. The most popular research area of articles indexed in the WoS database referring to the concept of urban smart mobility between 2000 and 2017

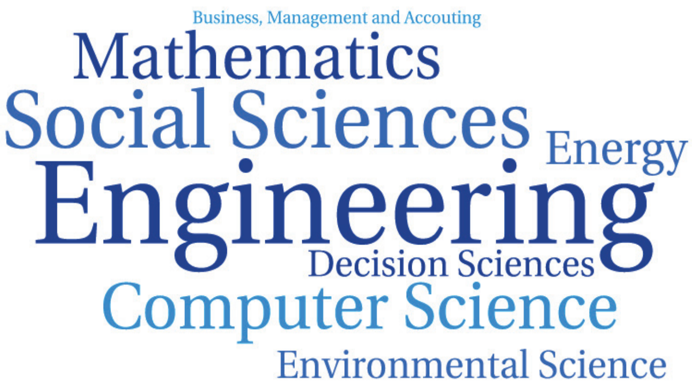

Fig. 4. The most popular subject area of articles indexed in the Scopus database referring to the concept of urban smart mobility between 2000 and 2017

Tab. 1. The most cited articles dealing with urban smart mobility or intelligent transport system in the Scopus database published between 2000 and 2017

Position in the ranking	Name of database	Author	Title of publication	Source	Year of publication	Times cited
1	Scopus & Web of Science	Quddus, M. A., Ochieng, W. Y., & Noland, R. B.	Current map-matching algorithms for transport applications: State of the art and future research directions	*Transportation Research Part C: Emerging Technologies*, *15*(5), 312-328	2007	398 (Scopus) 297 (WoS)
2	Scopus & Web of Science	Batty, M. et al.	Smart cities of the future	*European Physical Journal: Special Topics*, *214*(1), 481-518	2012	304 (Scopus) 241 (WoS)
3	Scopus & Web of Science	Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., & Scorrano, F.	Current trends in smart city initiatives: Some stylised facts	*Cities*, *38*, 25-36	2014	265 (Scopus) 209 (WoS)
4	Scopus	Lee, U. et al.	Mobeyes: Smart mobs for urban monitoring with a vehicular sensor network	*IEEE Wireless Communications*, *13*(5), 52-57	2006	207
4	Web of Science	Min, W., & Wynter, L.	Real-time road traffic prediction with spatio-temporal correlations	*Transportation Research Part C – Emerging Technologies*, *19*(4), 606-616	2011	157
5	Scopus	Pelletier, M. P., Trépanier, M., & Morency, C.	Smart card data use in public transit: A literature review	*Transportation Research Part C: Emerging Technologies*, *19*(4), 557-568	2011	201
5	Web of Science	Hidas, P.	Modelling lane changing and merging in microscopic traffic simulation	*Transportation Research Part C – Emerging Technologies*, *10*(5-6), 351-371	2002	145

with Fig. 3. The concept of smart mobility is a pillar of a smart city strong linked with transportation issues (routing, digitalisation services, road traffic prediction, etc.), municipality decisions and strategy, based on information and communication tools and technologies.

The literature review was preceded by a bibliometric analysis based on the Scopus database, which enabled the authors of the article to indicate the tendencies and trends in the field of urban smart mobility research. As a part of the analysis, the authors identified key terms appearing most often in articles dealing with urban smart mobility or urban intelligent transport system published in the Scopus database in the last 17 years. To present a clear visualisation, this paper focuses on those key terms which were recorded at least ten times within the group of publications being studied were considered (Fig. 5).

Within the conducted analysis, it was possible to notice three most frequent keywords, such as transportation, urban transport, and intelligent systems. Key terms which came up repeatedly included intelligent transport system, urban transportation, smart city, mobility, vehicles, electric vehicles, and intelligent vehicle highway system. There was a group of keywords connected to particular categories of advanced computer analysis, most of these applied in software applications developed for smart mobility: computer simulation, modelling, optimisation, algorithm, numerical model, forecasting, Ad Hoc Networks. It is also possible to see keywords closely linked to the implementation of ITS referring to traf-

Fig. 5. Key terms which come up repeatedly in publications in Scopus database in years 2000-2017

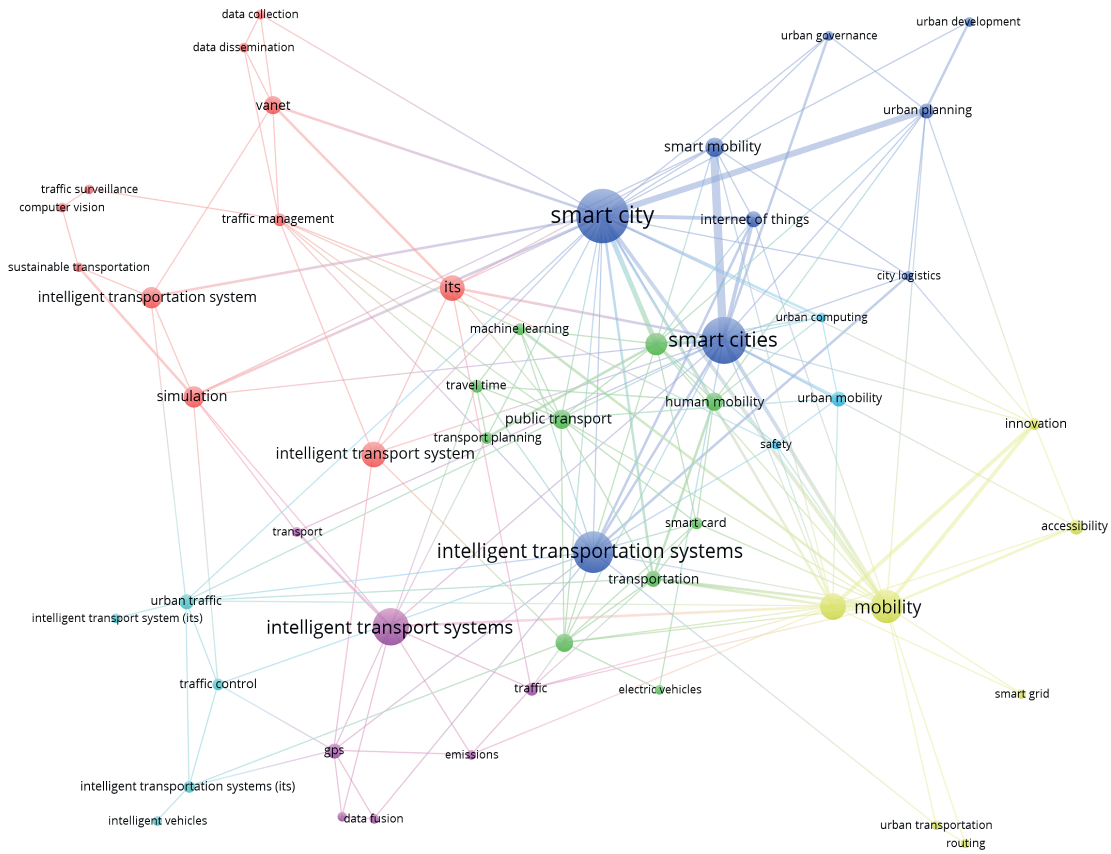

Fig. 6. Map of current research trends based on co-occurrence of the authors' keywords in publications referring to urban smart mobility or intelligent transport system from the Scopus database in the years 2000-2017

Source: authors own study using VOSviewer Software.

fic problems: traffic control, traffic congestion, travel time, roads and streets, urban traffic, traffic surveys, transportation planning, real-time, advanced traffic management systems, street traffic control. The next group was words related to elements of public transport: mass transportation, busses, and public transportation. A separate group of keywords were related to the environment such as air quality, sustainable development, and sustainability. Other smart city challenges related to city crowding were reflected by some keywords, such as urban growth, urban areas, urban mobility, and urban planning. It should be noted that there were also names of countries and regions, for example, Italy, United Kingdom, United States, Canada, China, Europe, and Eurasia.

In the next part of the study, the authors created a map displaying relations between the analysed keywords. The central part of the map shows key terms which appear the most frequently. Based on the data presented in the Fig. 6, some tendencies may be observed (the size of the point and font representing each term show the frequency with which this key word occurs). First, the resulting network is characterised by numerous connections and looks rather dense.

The VOSviewer software enabled authors to determine how often each item occurred within the network as well as how often the elements were cited together. The use of the program also facilitated the combining of the analysed set of data into clusters which were then marked out on the map in different colours. The program discerned 7 clusters of terms' co-occurrences which, all together, included 52 words. It must be said that being a member of a given cluster meant that the given phrases occurred together most often, but it does not preclude them from occurring with other terms. The main points referred to in most works included especially a smart city, smart mobility, intelligent transport system, sustainability, and mobility. The first cluster was located around the term a smart city, which co-occurs most frequently with such terms as smart mobility, urban planning and intelligent transport system. Concepts which had the strongest links to others within the network were the same as the terms listed above. The issues most strongly connected with others within the network (which appeared most often in the analysed set of publications and had the highest co-occurrence ratio), were: a smart city, intelligent transportation system, big data, sustainability, and public transport (Tab. 2). Authors of the article proposed the name of each cluster considering the majority of terms that each cluster contains.

The first resulting cluster "Computer simulation of urban traffic" is composed by a combination of important topics of Computer Science, namely Computer Vision, Simulation, Data Collection and Vehicular Ad Hoc Networks (VANET) with their applications in the transportation sector, traffic surveillance and traffic management. According to the literature, the research and development trends in computer simulation and urban traffic fields aim using and implementing machine learning algorithms for improving the accuracy of applications dedicated to lane keeping, prevention of collisions, self-driving cars, simulation of new routes or forecasting new traffic scenarios, etc (Mobileye, 2018). Machine learning algorithms, especially the artificial neural networks, represent one of the main trends in Computer Vision (constantly evolving), which helps in solving some of the hardest problems of the urban traffic. The reduction in traffic accidents is planned by using embedded systems based on Computer Vision which projects the existing image from the front of the truck on its back to help other traffic participants who want to overtake the truck (Samsung Electronics, 2015). There is an increasing opportunity in intelligent transport systems to adopt Computer Vision and video analysis for traffic measurement (Buch et al., 2011; Petrosino & Salvi, 2015). The next stream of research within the cluster 1 concerns the research on Vehicular Ad Hoc Networks (VANET), related to their security features, challenges, attacks (Mokhtar & Azab, 2015), and the challenge of routing (Li & Wang, 2007). Future research trends identified in the literature which are related to Computer simulation of urban traffic focus on the development of effective algorithms of managing urban traffic and simulate network-wide traffic efficiently (Nellore & Hancke, 2016).

In the second cluster "Urban public transport", the merging of Computer Science concepts with those specific to Urban Public Transport may be observed. Aiming for a more effective urban public transport, the public is engaged in city-related decision-making by using ubiquitous smart devices and applying the Gamification concept, also crowdsourcing and crowdsharing data to create the premises of big volumes of data. Machine-learning and smart cards are useful in adding intelligence to any devices, enhancing mobility, implementing smart parking systems, traffic lights controllers, etc. In the works by Dobre and Xhafa (2014), based on solutions designed

Tab. 2. Clusters identified through the analysis of co-occurrence of the authors' keywords

Items	Occurrences	Co-occurrence
Cluster 1 "Computer simulation of urban traffic"		
Computer vision	4	2
Data collection	4	3
Data dissemination	4	3
Intelligent transport system	14	6
Intelligent transportation system	11	5
ITS	14	9
Simulation	8	11
Sustainable transportation	4	3
Traffic management	6	9
Traffic surveillance	4	2
Vanet	9	6
Cluster 2 "Urban public transport"		
Big data	12	14
Electric vehicles	4	2
Human mobility	9	7
Machine learning	5	6
Public transport	10	13
Smart card	5	7
Transport planning	5	4
Transportation	8	9
Travel time	6	7
Urban transport	9	12
Cluster 3 "Urban smart transport planning"		
City logistics	4	6
Intelligent transportation system	26	15
Internet of things	8	6
Smart cities	31	21
Smart city	37	24
Smart mobility	10	9
Urban development	4	2
Urban governance	4	4
Urban planning	7	9
Cluster 4 "Innovations in urban transportation"		
Accessibility	7	4
Innovation	5	7
Mobility	20	20
Routing	4	2
Smart grid	4	2
Sustainability	15	14
Urban transportation	4	3
Cluster 5 "Data fusion in ITS"		
Data fusion	4	3
Emissions	4	4
GPS	7	8
Intelligent transport systems	23	10
Localization	4	3
Traffic	6	7
Transport	4	3
Cluster 6 "Intelligent solutions in urban traffic"		
Intelligent transport system (ITS)	4	1
Intelligent transportation system (ITS)	5	5
Intelligent vehicles	4	1
Traffic control	5	5
Urban traffic	7	9
Cluster 7 "Safety of urban computing"		
Safety	4	6
Urban computing	4	5
Urban mobility	7	5

Source: authors own study using VOSviewer Software.

to support the next-generation Big Data applications, cities are emphasised as areas with Big Data having a direct impact on the quality of life in a city. It should be pointed out that this data can be very useful to transit planners. According to Weziak-Białowolska research (2016), the dissatisfaction with public transport contributes significantly to the dissatisfaction with life in a city. Promoting the use of urban public transport helps in decreasing traffic congestion and air pollution in cities and improving human mobility, which is mostly related to management of passenger transport means (Yue, Chye & Hoy, 2017). Another important aspect of research in this field is smart card systems, which produce large quantities of very detailed data on onboard transactions and is often used by public transit agencies (Pelletier et al., 2011). In relation to urban public transport trends, we may state that the situation depends on the development degree of each country. The developing countries must improve their infrastructure and apply new features of public transport inside and outside the cities while the developed countries put their efforts in research studies to find new solutions that combat the city crowding or that reduce air and noise emissions, etc. Large cities often have a high demographic density and in consequence make a greater effort to develop their public transportation systems (Jun, Kwon & Jeong, 2013). The recent research trends identified in the literature and related to urban public transport, mainly focus on the possibility of prioritising public transport and reducing the time of travel (U.S. Department of Transportation, 2017; Jimenez, 2018).

The third cluster "Urban smart transport planning" is located in the map's centre and involves the general notion of a smart city. As already mentioned, smart mobility represents just a dimension of the smart city concept but one very important, strongly interrelated with other dimensions, such as the smart environment or smart living. The main task of a municipality (city) is to plan, govern and apply developmental solutions to make the public transportation easier to use and more reliable. The "Urban smart transport planning" is a wide area of research, in which researchers also analyse the problems particular to all other clusters. Despite the common goal, urban transportation planning has no universal solution (what works in one place does not work in another). The problem is critical in large cities with millions of inhabitants or in developing cities faced with an increasing rate of urbanisation. The planning initiatives involve the allocation of special lanes for the public transport and creation of incentives for electric mobility, all of these actions aimed at changing and extending the existing urban infrastructure. Many good measures in this field do not necessarily emerge from research but also from exchanges of good practice between cities that have implemented smart city features. Researchers define qualitative and quantitative indicators to measure the quality of planning solutions (emission estimations, travel time, customers served within a specified time frame, etc.). The importance in domains, such as urban planning, sustainable mobility, transportation engineering, and transport planning, has been identified by many researchers (Batty et al., 2012; Neirotti et al., 2014; Mangiaracina et al., 2017). The interest of researchers in planning and designing of urban transport systems will definitely show an upward trend in the coming years due to the increasing problem of congestion in cities.

The fourth cluster "Innovations in urban transportation" which has been widely studied in the last decade, mostly represents a further challenge regarding mobility, namely, to bring innovative solutions to urban transportation in a mobility world but keep the sustainability target. The technology innovation and intelligent (green) solutions for urban transport systems are of strategic importance for the EU, which allocates significant funds for research in this field (Halicka, 2016). Starting with 2012, the EU developed the European Innovation Partnership in Smart Cities and Communities aiming to connect all local initiatives (of the government, businesses and community-based organisations) from EU countries and provide exchanges and assistance tools regarding smart city solutions that meet specific local needs. Such initiatives aim integrating quality services with improved accessibility into the urban transport network, providing passengers with real-time multimodal information, enhanced comfort (Gaggi et al., 2013). The essential direction of future research trends should concentrate on improving the integration of new shared mobility services with traditional public transport services, autonomous vehicles, car park management and car sharing services, which have already reshaped our life and another various smart mobility services (Yue, Chye & Hoy, 2017; Fagnant & Kockelman, 2015; Jalali et al., 2017) and solving environmental problems caused mainly by traffic congestion (Florea & Berntzen, 2017).

The fifth cluster "Data fusion in ITS" is based on using and extracting data regarding transport, route difficulties and traffic, and developing smart applications to reduce air pollution, reduce car traffic, emphasising the Mobility as a Services (MaaS) concept, providing very accurate, real-time, customised, wireless mobility information services regarding travel planning, journey time, air quality, online booking and payment facilities. In the last few years, the Global Positioning System (GPS) has been a major positioning technology for providing location data for ITS applications. According to the literature review by Quddus et al. (2007), a map-matching algorithm (which integrated positioning data with spatial road network data) could be used as a key component that supports the navigation function of ITS to improve its performance. The fifth cluster "Data fusion in ITS" is developed relatively recently and might exponentially evolve due to the pervasive computing, crowdsourcing, and a large amount of data provided by almost any sources. Data obtained from interconnected cars will be used by analytical tools to predict vehicle malfunctions and help the user to make a brief diagnosis after they notice car problems, discovering the reason and indicating the nearest auto service. The Mobility as a Services (MaaS) is a recent research trend and innovative transport concept, which may have a significant impact on current transport practices (Jittrapirom et al., 2017). The MaaS becomes more powerful, benefiting from innovations and research in wireless mobility information services like 4G/5G networks (Goodall et al., 2017). This abundance of data and means of retrieval, leads to mandatory research of the 7th cluster identified by us, which pursues keeping privacy and security of user data.

The cluster 6 "Intelligent solutions in urban traffic" was located on the margins of the map because it concerned one of less frequently occurring keywords. The implementation of ITS solutions brings several benefits for all road users: pedestrians, cyclists, public transport, drivers and the environment. The future research related to intelligent solutions should focus on improving intelligent traffic lights, intelligent, autonomous vehicles (Fagnant & Kockelman, 2015) and improving traffic control. The positive effects of ITS potential, namely traffic management in real-time, providing reliable and real-time updated information to the users (including unexpected road events) are well studied and established in the literature (e.g. Kolosz & Grant-Muller, 2015; Grant-Muller & Usher, 2014).

The last and simultaneously the smallest cluster 7 "Safety of urban computing" consist of only three items but is very critical ("safety" into "smart mobility" inside and outside the city) according to recent statistics that correlate injuries and car accidents to the lack of infrastructure and poor roads. Some publications are aimed at identifying the benefits of Information and Computing Technologies (ICT) in a Smart City and of the Internet of Things, which are tremendous (Adel et al., 2014). For instance, the research of Bitam and Mellouk (2012) proposed a cloud computing model (called ITS-Cloud) applied to the Intelligent Transportation Systems, which improves transport outcomes such as road safety, transport productivity, travel reliability, informed travel choices, environment protection, and traffic resilience. The recent research trends related to the safety of urban computing mainly focus on improving data reporting systems, monitored using reliable data that can be publicly shared (e.g. Welle et al., 2018).

The main trends of research areas that appear in scientific articles published in years 2000–2017 dealing with urban smart mobility and intelligent transportation system are those which refer to the smart city, sustainability and public transport. The latest key terms characterising published articles besides phrases connected to the smart city and intelligent systems refers to, i.e. traffic control, vehicles, traffic congestion, big data, urban planning and mass transportation.

Conclusions

From the scientific point of view, those analyses lead to following conclusions:

- there is a systematic increase in the interest among academics in the analysed field of study between 2000 and 2017;
- the analysis allows indicating the urban smart mobility and intelligent transport system as rapidly developing fields of study, characterised by essential issues for future cities and the main contributions in the field comes from Computer Science and Transportation Science Technology researchers;
- in the last five years, there has been an enhancement in the production of scientific papers dedicated to smart mobility;
- the conclusions of this study can be used by municipalities, the business sector, and researchers to determine the trends in the smart mobility field and to choose proper decisions for improving the quality of life of citizens;
- a strong research trend consisted of the analyses referring to the smart city, intelligent transportation system, big data, sustainability and public transport;
- from the perspective of looking for future research gaps in the analysed context, infrastructure design and air quality protection, climate change, and city crowding were less frequent areas in the scientific literature. Regarding the future cities, the infrastructure is not taking into account "as much as it should", urban planning and the transport system is not designed considering the industrial developments and the prediction of the population that will live in cities. The air quality factor and the environment are only considered to a small extent although traffic problems have a direct impact on the environment, human health and, ultimately, the economy.

Also, the machine learning concept will be ubiquitous in future smart devices and applications implemented not only to mobility and transport systems;

- at the end of our analysis, we propose 7 clusters of term co-occurrences of most author keywords in publications referring to urban smart mobility or intelligent transport system.

Authors have chosen to analyse articles published in two most representative databases and conducted the co-occurrence analysis on articles listed in on Scopus database. As a further work, the scope of analysis should be expanded to include works indexed in other databases (for example SpringerLink, ScienceDirect, EBSCO etc.). The bibliometric analysis is still one of a few sources allowing for the wide perspective of the issues undertaken by scientists as well as familiarising with the development directions of a given issue.

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One-page strategic plan: the case of Aarong company from Bangladesh

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ABSTRACT
Strategic development and planning predetermine all the major fields of activities. Marketing activities are the key tool of communication with a company's customers, suppliers and other stakeholders. Nowadays, short but informative presentation solutions are becoming more attractive and popular. Companies are using more visuals with a short text in their communication channels as well as in building strategies. One of the tools is the one-page strategic plan (OPSP). The research problem of the paper is how to develop a strategy in its compressed version for the organisation that can have a format which is easy-to-understand and communicate. The paper aims to propose the OPSP model for the Aarong company, which should include both the commercial and non-profit activities. As a research method, the case study of Aarong company was chosen, using the secondary data. The proposed OPSP for Aarong company clearly showed the connections of all key elements of a strategic plan. The practical implications of using the OPSP tool in the Aarong company are clearly visible in terms of synthesis of a complicated strategic plan and having an attractive form of the company strategy for the external communication.

KEY WORDS
strategic planning, one-page strategic plan, marketing strategy, non-profit, Bangladesh

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Introduction

Modern companies notwithstanding the size or the type of activities, base their operations on strategic plans (Jalkala et al., 2010; Majetun & Mikoláš, 2017). Companies need to develop a strategy and establish clear goals before taking appropriate actions to increase the probability of achieving the results (Bartkus, Glassman & McAfee, 2006; Buzzell, 2004). Marketing activities, including trade fairs (Siemieniako & Gębarowski, 2016; 2017), are related to the key tools of communication with a company's customers, suppliers and other stakeholders (Kotler & Keller, 2014). Nowadays people are overloaded with information. That makes short and informative methods of information presentations more attractive. That is why companies are using more visuals with a short text in their communication channels. It is not surprising that brief graphical representation is used in building strategies as well, and one of the most popular tools is the one-page strategic plan (OPSP) (Vishnevskiy, Karasev & Meissner, 2016). From a corporate point of view, a strategy is a background for designing all the marketing activities because it helps to recognise the company's philosophy and values; it shows key targets and milestones; and ensures acknowledgement among company's customers and other stakeholders (Phaal & Muller, 2009).

This research explores how to develop a short version of the strategy, namely, the one-page strategic plan, which encompasses both the commercial and non-profit activities. Furthermore, it explains how to elaborate a format of the strategy that is easy-to-understand and communicate. The paper aims to propose the model of the one-page strategic plan for the Aarong company from Bangladesh, which should include both the commercial and non-profit activities. As a research method, the case study of the Aarong company was conducted, using the secondary data.

1. Research background

Aarong – "village fair" in Bengali – is the most popular lifestyle retail chain in Bangladesh (Anon, 2016a). This ethical brand originated in 1978 as an easy and natural way to empower rural artisans, especially women, to rise above poverty (Anon, 2016a). The idea of this company belongs to BRAC (Building Resources Across Communities) – the world's largest development organisation (Anon, 2016b). For a start, it has engaged a small number of rural women to produce crafts and established Aarong to pay them for their goods on time. The company kept growing: in 1978, its retail space was only 1.6 thou. sq. ft, and in 2013, it already had 194.1 thou. sq. ft.; the company's sales grew from Tk 2400 Million in 2008 to Tk 4530 Million in 2012 (Anon, 2016b).

Aarong uses decentralised manufacturing process to accomplish its goal as a social business by employing production workers in various rural and semi-urban areas; while a purely commercial business would locate its production centres in concentrated areas where infrastructure and low-cost labour supply are available. Many of the products are produced in off-site locations by workers who have very little exposure to the final products that are sold at the retail level (Anon, 2016b).

The Aarong company produces a wide range of goods, such as clothing, jewellery, fabrics, non-textile crafts, leather goods, footwear, houseware. All of the products are made in traditional Bengali style by women from villages in Bangladesh. Aarong is among the first companies that identified itself as "Made in Bangladesh" (Anon, 2016a). The positioning makes a huge impact on designing all the further marketing activities and communication with their key stakeholders. From the authors' point of view, the main difference of Aarong from other companies is that it follows both commercial and social goals. For the purpose of this paper, the research was made in two directions. First, the company's policies towards the manufacturing process, promotion, product distribution, and motivation towards the personnel were analysed. Secondly, the research included analyses of the microenvironment, such as culture, economic situation, the situation of the women in terms of equality, professional life, etc. In other words, the analyses considered all the essential factors that contribute to the functioning of the company as well as its employees, customers, donators, and other stakeholders.

Aarong has achieved rather high results in fighting rural poverty. Its current services to the artisans include free skill-building, the supply of raw materials for production, transportation of goods, quality control, storage, management, finance, marketing, and microfinance loan options through Aarong (Anon, 2016a). Working mothers have access to day-care centres for their children while they work, and senior workers receive a retirement benefit. Aarong employees are also provided with various support from BRAC, including services, seeds, agricultural, poultry, livestock, and fisheries support; free schooling for their children; subsidised tube-wells and sanitary latrines; healthcare including free eye check-ups and glasses, free treatment of tuberculosis and severe illnesses, and health education; as well as legal awareness and support. Currently, a health security scheme for artisans and their family members is being piloted to protect artisans against catastrophic health expenditures (Anon, 2016a). All this shows that Aarong successfully builds its non-profit activities on the outcomes of the commercial processes.

2. Literature review

The term "strategy" originates from the Greek words "strategos" (the army) and "agein" (to lead); thus, "strategy" is "the art of leading the army" (Aartsengel & Kurtoglu, 2013). The paradox of strategies is that on the one hand, they refer to strategic plans to guide the company's future and, on the other hand, to the current strategic position (Grünig & Kühn, 2015). Strategic planning is a methodology used to guide the work of an organisation with the focus on the long-term objectives, vision and mission and their deployment (Chiarini, 2015). Strategy arises from many small steps that are not oriented towards overall long-term goals, but towards solving urgent short-term problems (Grünig & Kühn, 2015). Strategic planning is used to recognise and describe alternative courses of action.

Marketing is always one of the central elements of strategic planning because it covers all the important aspects connected with the company's products, clients, partners, and communication with them. Marketing is focused on the description and explanation of widely understood social phenomena (Mitręga, 2014). Marketing plays a significant role in determining the strategic orientation and performance outcomes of the firm (Hunt & Morgan, 2005). It is mainly marketing, which is responsible for developing relationships with customers and building their loyalty (Siemieniako, 2010; 2011; Mitręga, 2013). Strategic marketing planning is a process of creating marketing strategies by a company and planning their implementations. A marketing strategy plan has a dual nature because it focuses on two key components: target market and product, or value proposition (Smith, 2003). Strategic marketing plays a critical role in linking the organisation to its environment and helps it to be proactive (being prepared to adapt to the environment or impact on it); it is important for the organisational success; marketing strategy can be vital for achieving the objective of the superior performance (Aghazadeh, 2015).

The main function of the strategic planning is to develop a shared vision of its policies, goals, objectives, and activities; and to verify the planned trajectory of the organisation (Bernstein, 2014). The main components of strategic planning are a vision, mission, goals, and the identification of key stakeholders, followed by tactical or operational goals. The vision represents an ideal state, long-term aspiration to the future, for over five years, which shapes a possible and desirable development of an organisation (Ciucescu, 2015, p. 63). As Fig. 1 shows, the key attributes that should be included within the vision are: (1) it should be a short sentence, (2) it should be easy to understand for the company's employees as well as the public, (3) it should not contain any quantifiable elements (Ciucescu, 2015, p. 63).

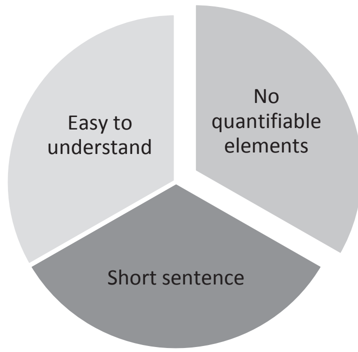

Fig. 1. Attributes of a vision

Source: elaborated by the authors on the basis of (Ciucescu, 2015).

Sometimes, there can be some confusion between mission and vision, because both of them communicate the purpose of a company's existence. The key difference between them is that a vision of a company is focused on tomorrow and what the company wants to become, while the mission is focused on today and what the organisation does (Skrabanek, 2017). In other words, a mission statement can be defined as a broad declaration of the basic, unique purpose, and the scope of operations that distinguish the organisation from others of its type (Gulati, 2013).

As Fig. 2 shows, in defining the mission, an organisation should focus on three dimensions: (1) consumer groups (who are to be served and satisfied); (2) consumer needs (what are to be satisfied); and (3) approaches (how consumer needs are to be met) (Bernstein, 2014).

A mission should be achievable, motivating, and distinctive (Bernstein, 2014). To achieve the ideal future described in the vision, a company should specify its actions into smaller steps that can be called goals. Goals are broadly worded statements that set a framework for the delineation of a series of clear, specific, and measurable objectives (Dolan, 2003).

Nowadays, companies realise the importance of the stakeholder management, that is why they include this group in the development of a strategy (Bartkus, Glassman & McAfee, 2006; Feurer & Chaharbaghi, 1995). Diverse stakeholders in a company may have

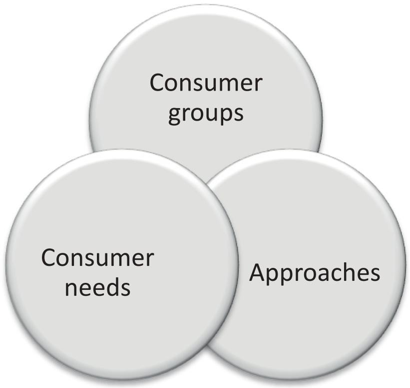

Fig. 2. Chief dimensions for designing a company's mission

Source: elaborated by the authors on the basis of (Bernstein, 2014).

different perceptions of what they most value (Bernstein, 2014). The statistics show that customers are the most commonly mentioned stakeholder groups, followed by employees, and investors; among the least frequently mentioned are the society and suppliers (Bartkus, Glassman & McAfee, 2006). The order can be changed depending on the types of activities of a particular company. It is believed that including the most critical groups of stakeholders into strategic plans can help keep the focus of a company on the right efforts (Bartkus, Glassman & McAfee, 2006).

Processes of the strategic planning can vary depending on the type of company's activities. Whereas companies whose main aim is profitmaking have a possibility to set a well-defined goal of profit maximisation, non-profit organisations have to elaborate on a more complex set of goals and apply different measures of success (Bernstein, 2014). Strategic planning is the process through which a company determines its strategy (how it will get there), identify the necessary resources (what it will take to get there), and evaluate the results (how to understand if it has gotten there) (Bernstein, 2014; Aghazadeh, 2015). According to Bernstein, the strategic planning process consists of the following steps (Bernstein, 2014):

- strategic analysis: (a) assess the organisation's strengths, weaknesses, opportunities, and threats, and (b) analyse the organisation-wide mission, objectives, and goals;
- market planning: (a) determine the objectives and specific goals for the relevant planning period, (b) formulate the core marketing strategy to achieve the specified goals, and (c) establish detailed programs and tactics to carry out the core strategy;
- marketing plan implementation: put the plan into action;
- control: measure performance and adjust the core strategy, tactical details, or both as needed.

The strategic plan describes the target markets' and the firm's value proposition based on an analysis of the best market opportunities (Kotler & Keller, 2014). The strategic planning process does not attempt to detail the specifics of how the strategic initiatives are to be achieved; it aims to identify key milestones (Dolan, 2003). The tactical (or operational) marketing plan is more detailed and specifies the marketing tactics, including product features, promotion, merchandising, pricing, sales channels, and service (Kotler & Keller, 2014). Short term marketing plans specify the marketing goals and objectives of businesses and outline how resources will be used toward achieving the marketing results (Camilleri, 2017).

The one-page strategic plan (OPSP), as the name explains, is a type of presentation of a company's strategy that fits one-page. It includes information about the mission, vision, goals, as well as other vital information, normally in an image format (Vishnevskiy, Karasev & Meissner, 2016). Other information includes the most important strategic value-creating actions and entities that are involved in a relationship with the company (Vishnevskiy, Karasev & Meissner, 2016). The OPSP scheme or visualisation should also contain appropriate connections between all kinds of elements.

3. Research method

This paper is based on the example of the Aarong company from Bangladesh. Bangladesh is a developing country where religion, values, and traditions play an important role in a family's lifestyle, the professional perception of an individual, economic and commercial components of life. Connection with traditions can be especially observed in poor and rural areas due to low representation of well-educated people (Anon, 2016b). Based on the analysis of secondary materials, it can be said that historically women were responsible for maintaining the home, including cooking and cleaning, as well as sewing clothing, making accessories, home decorations, and kitchen utensils. Time passed by, and women gained access to the labour market and needed to earn money. However, according to the authors of this paper, women still lack required skills and knowledge to secure jobs as qualified specialists, and traditions prevent many of them from getting educated (Anon, 2016a). Consequently, there was a clear need to establish a company that would give women access to the labour market, and ensure them with guaranteed earnings using the skills they already have and creating a supportive working environment.

The case study as a research method was chosen because it allows making vast qualitative research of the data from different perspectives of the Aarong company's functioning, in other words, it allows to study both micro- and macro environments of this Bengali company. Aarong's and BRAC websites as well as Aarong's annual reports were used.

The observation method was also used and related to the wider environment of the Aarong company. The following issues were observed and analysed: culture, economic situation, the situation of women in terms of equality, professional life, etc. Considering that one of the authors of this paper is Bengali, has lived in Bangladesh till 2016, and still has some connection, it can be said that the research is based on the experience of this person having a deep understanding of the Bengali's culture, mentality, social layers, especially the position of women. Based on this author's analysis of the local media, such as newspapers, magazines, TV, and radio, the environment of the Aarong company was recognised.

4. Research results

The OPSP is elaborated from the analysis of the Aarong company and its activity and also based on the analysis of the Aarong environment, i.e. the situation of the Bengali women. Fig. 3 presents the proposition of the OPSP for the Aarong company. The solution was designed by the authors of this paper. It has the following parts: the vision, mission, five-year strategic goals, the indication of the main entities and key Aarong actions directed towards these entities. It also shows different kinds of stakeholders that have some influence on the Aarong activity.

The "commercial flower" contains the following activities: (1) establishing strong partnership, (2) creating common projects of Aarong products together with distributors, (3) expanding the international retail chain, (4) offering an individual and unique design of the Aarong handicraft products, (5) opening an Internet shop for Aarong products. The leaves of the flower show what measures should be taken to achieve Aarong's goals connected with the increase in the loyalty of partners, expanding the retail chain and increasing sales, i.e. commercial interests of the company are in focus. For the interests of the customers, it is reasonable to open an Internet shop, making access to the products much easier and leaving less importance to the country's borders. This also requires to expand the international retail chain. Unique and individual design helps customers feel more special possessing rare products. Speaking about partners, like in any other business they are interested in strong partnership so that it would be possible to make long-term cooperation as well as financial plans. Also, when there is an option for making personification of products, partners can be engaged in the process of designing those products to satisfy their specific needs. In this case, the leaves "offering unique products" and "involving partners in designing products" are interrelated because sometimes partners can have a better understanding of a particular group of customers and can help design products that fit the market better.

The "non-profit flower" activities: (1) creating more working zones for women, (2) creating a supportive environment for the Bengali women, (3) supporting initiatives that promote women's rights. These activities are taken to achieve the social goal of increasing the share of the Bengali women influenced by the Aarong programmes. In the case with this flower, it is more complicated to identify for which particular group an activity is intended because all the benefits for the Bengali women are the benefits for the society. So, it can be concluded that through the improvement of life for the Bengali women, Aarong makes positive changes in the Bengali society in general.

There are also two leaves that unite both flowers: (1) increase the social responsibility and (2) promote the Bengali culture. They are in-between because those activities are of the same importance for both groups of the key stakeholders: the Bengali women, related society, customers, and distributors. All of them will benefit from the actions mentioned above, including the Bengali women and the related society through the increase of the level of interest towards national culture and, perhaps, growing number of the social support programmes. Customers and dis-

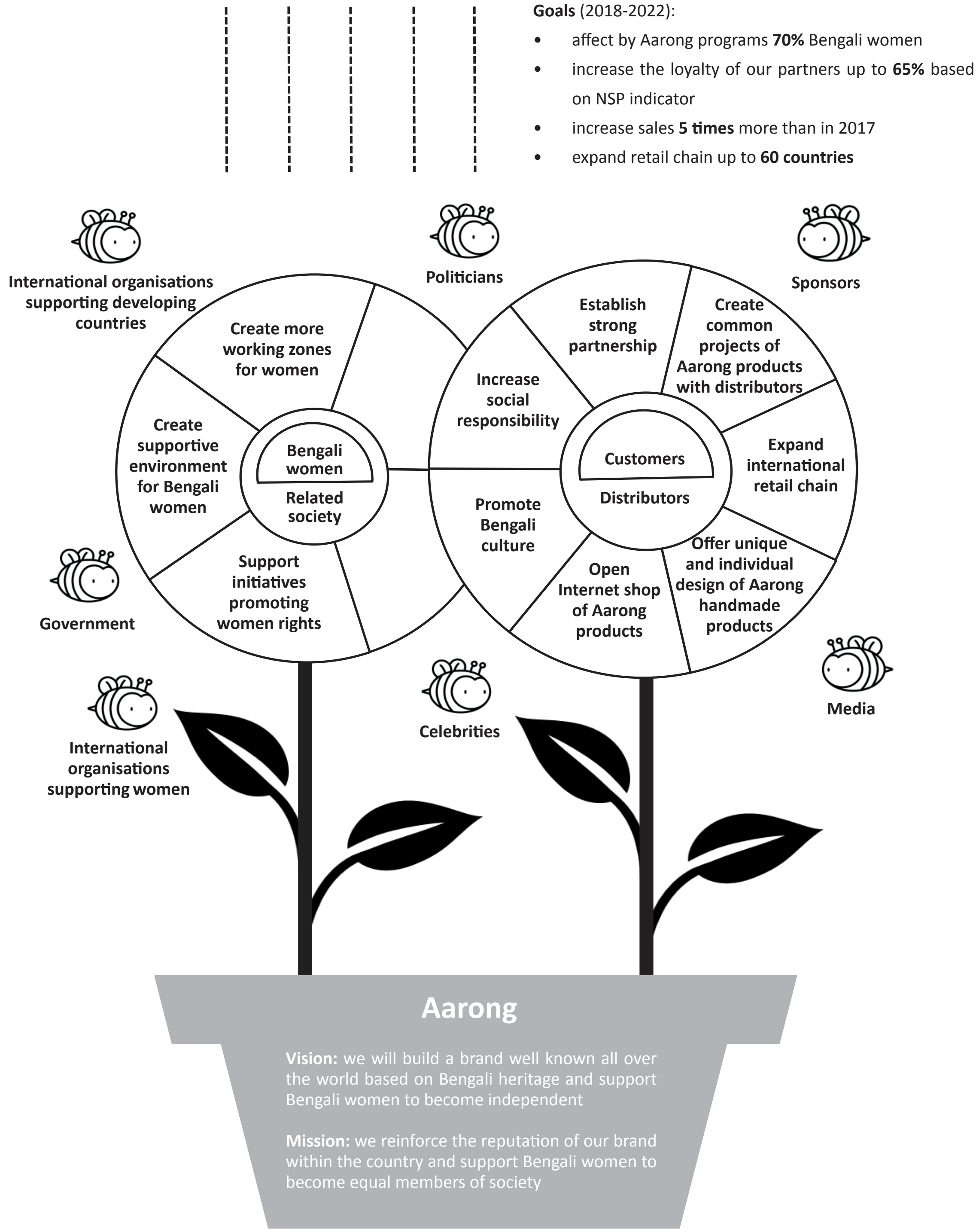

Fig. 3. One-page strategic plan scheme for the Aarong company

tributors do not just act in their commercial interests but realise their social mission through support towards the social company. Although only those two leaves are in common between the flowers, all the activities of the company contribute to both commercial and non-profit goals. For instance, designing and offering unique and authentic products promotes the Bengali culture. Demand for the products will impact on the demand for labour, giving access to the labour market for more women. And vice-a-versa, providing all the necessary support for the Bengali women will increase the quality and variation of Aarong products, increasing the market share of the company.

Besides those four groups of key stakeholders, there are external stakeholders as well, who are influenced by Aarong activities. Politicians and government, as well as NGOs supporting women and developing countries, for instance, benefit from Aarong taking part in solving important problems of the society; the company spends money and other resources to achieve its social mission. At the same time, those groups of stakeholders can support Aarong's activities and programmes. Media and celebrities can take part in the promotion of Aarong products and social programmes. On the one hand, this makes Aarong's programmes popular, on the other – celebrities and media show their active position in supporting the Bengali culture and helping people in need. Sponsors as well can manipulate their reputation by supporting particular kind of organisations and businesses.

Both flowers grow in the pot which symbolises activities rooted in relation to the vision, mission and strategic goals of the Aarong company. The existing vision of Aarong is "to create a world free from all forms of exploitation and discrimination where everyone has the opportunity to realise their potential" (Anon, 2016a). It is evident that even though among profit generation from Aarong's products is among the key activities of the company, this vision does not cover a commercial part of the activity. That is why the proposed vision is: "We will build a brand well known all over the world based on the Bengali heritage and support the Bengali women to become independent". The proposed version does not focus on profit maximisation either, although it includes information about the increase of recognition of the company's brand. The situation with the mission is rather similar as it covers only the socially oriented part of the company's activities. The existing mission seeks "to empower people and communities in situations of poverty, illiteracy, disease and social injustice. Our interventions aim to achieve large scale, positive changes through economic and social programmes that enable men and women to realise their potential" (Anon, 2016a). The proposed mission reads: "We are reinforcing the reputation of our brand within the country and support the Bengali women to become equal members of the society", which has, as it has been described in the previous chapter, consumer groups (the Bengali women), consumer needs (becoming equal members of society), as well as the key direction of the commercial development of the company (reinforcing the reputation of the brand). The existing objectives of the company are: (1) creating job opportunities; (2) generating the surplus for BRAC to minimise donor dependency; (3) ensuring long-term support and contribution towards the sustainability of BRAC's development interventions such as microfinance, education and skills development; (4) ensuring viable investments in the long run to act as a 'hedge' against future liquidity (Anon, 2016a). For comparison, the proposed goals for the years 2018–2022, that are based on the proposed mission and vision, are: (1) 70% of the Bengali women are affected by Aarong programmes; (2) increased loyalty of our partners up to 65% based on the NSP indicator; (3) increased sales by five times compared to 2017; (4) expand the retail chain to up to 60 countries. The goals are measurable and limited in time.

Conclusions

On the basis of the analysis in this paper, it can be concluded that strategic planning and designing of marketing activities are the key success factors for modern companies existing in the market because they are based on detailed analyses of a company's internal and external environment. Whether a company has non-profit goals, or its main target is profit maximisation, or it joins both of those programmes, the company needs to understand, what are the main customers, stakeholders, goals, instruments and resources, and how to use the resources to achieve the results. This statement becomes rather clear after the analysis of the Aarong company and the development of the strategic plan. Socially-oriented and commercial goals of a company are quite interdependent. These joining commercial and non-profit areas of activities posit the Aarong company in a service logic (Siemieniako, 2008). By generating profit, a company can finance its social programmes, and vice-a-versa, in the case of Aarong, investments in the development of women and infrastructure, improves the quality and increases the variation of the products that in the end should contribute to the increase of the profits. Consequently, in designing a strategic plan and marketing activities, the specificity of the company that joins both commercial and non-profit activities must be considered, and on the one hand, the activities should be developed in both fields. Although on the other hand, the connection between them should be easy to follow and they should contribute to the common mission and vision.

As the research results of this article show, the OPSP is a practical tool that can be used by companies to communicate their plans with key stakeholders. The main advantages: (1) a short version of all the main outcomes from a strategic plan, (2) easy-to-understand language for all stakeholders, (3) attractive visual form that can be used in different communication channels. It is consistent with the study of visualisation of a strategy as a roadmap, that has "an architecture providing a coherent and holistic structure within which the development and evolution of the business or system and its components can be explored, mapped and communicated" (Phall & Muller, 2009, p. 39). Since the OPSP explains in an easy form what a company wants to achieve and when, what actions need to be taken, who is affected by its actions and who is interested in the outcomes of the company's activities, it creates a background for the promotional activities.

As the paper suggests, a strategic plan can be more than a document describing the long-term future of a company and the ways how this future can be achieved. The most important outcomes of this document can be extracted and presented attractively so that customers, employees, business partners and other stakeholders can see and realise all the attributes of the strategic plan.

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Intellectual property management in startups — problematic issues

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ABSTRACT
This paper describes the most important problems related to the management of intellectual property in startups. Startups have become an inseparable element of the innovative economy. Many of these companies base their development on intellectual capital and innovations. In this context, it is extremely important to legally secure the innovations and protect intellectual property. These activities can often be the decisive factor in the development of startups. This article aims to identify, analyse and evaluate the most important issues related to the management of intellectual property in startups. The first part of this paper presents the performed literature review, which mainly concerns the definition of innovation, the state of entrepreneurship in Poland, and the definition of a startup. The second part of the article deals with the main problems related to the management of intellectual property in startups. It is divided into three issues: underestimating the importance of intellectual property, the lack of intellectual property management strategies in startups and financial challenges of startups. The main results of the research indicate that many startups still have low awareness of what is intellectual property and what can be the consequence of using exclusive rights of others. The protection of intellectual property should become one of the elements of business strategies. However, startups find that the creation of the strategy and its implementation is rather expensive.

KEY WORDS
startup, intellectual property, strategy, management, entrepreneurship

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Introduction

Innovation is considered to be a key growth factor of competition and economic growth (Kononiuk & Nazarko 2014). Innovation is currently one of the most important factors of socio-economic development of countries and regions. All countries are designing development strategies based on innovations. Innovations are seen as a chance for rapid development and increased competitiveness in the international arena. The innovation of a given economy is measured through the number of submitted patents, the number of registered patents and the number of quoted patents. The number of patents shows the level of awareness regarding the need for protecting intellectual property, while the number of granted patents reflects the quality of solutions. Caring for intellectual property has a positive influence on the economy and patents, and other forms of intellectual property are a source of economic benefits. Many countries in the world saw increases in filing activity for patents, trademarks and industrial designs. Globally, a total of 3.1 million patent applications were filed with patent offices worldwide during 2016. About 1.3 million patent applications were filed with China's State Intellectual Property Office (SIPO). Other notable trends include large increases in trademark filing activity in Japan, the Russian Federation and India, and rapid growth in industrial design filing activity in the Russian Federation and at the European Union Intellectual Property Office (World Intellectual Property Organization, 2017). Patent applications filed by Polish inventors, companies and research institutions with the European Patent Office (EPO) grew by 14.1% in 2017, one of highest growth rates and well above the EU 28 (EPO, 2017).

Intangible properties are becoming increasingly important for innovative companies, especially small and medium-sized companies. The ability of companies to incorporate innovations is one of the most significant signs of their modernity, effectivity and productivity. Innovations are currently considered as the basic indicator of the development of a company, leading to the enrichment of the market in new products and services of high quality and organisational transformations within the company and its surroundings (Madyda & Dudzik-Lewicka, 2014). Strong competition forces companies to seek for new methods of production, the introduction of new products and improvement of existing ones. However, it is highly significant that the companies are aware of the intellectual capital, human resources and intangible properties in their possession, all of which can be of substantial value. The awareness of their existence and their correct identification can become one of the pillars of the success of the enterprise. On the other hand, the lack of protection of intellectual property rights or the improper securing of the purchase of such rights can put a developing enterprise in a difficult situation and even lead to legal disputes.

At present, startups have become an inseparable element of the innovative economy. Many of these companies base their competitive edge on intellectual capital and innovations. In this context, it is extremely important to legally secure the intangible goods belonging to a given company, as well as to constantly increase the knowledge on management and protection of intellectual property, especially in the area of effective transfer of technologies. These processes can often be the decisive factor in the development of startups.

The article aims to identify, analyse and evaluate the most important issues related to the management of intellectual property (IP) in startups. As part of the research, the authors reviewed the literature and current reports on the state of startups.

1. Literature review

Innovations are one of the most characteristic features of the contemporary economy. Innovation is the process of transforming new ideas, new knowledge into new products and services. The literature contains many definitions of innovation. Schumpeter classifies innovation into five categories as follow:

- the launch of a new product or species of the already known product,
- application of new methods of production or sales of a product (not yet proven in the industry),
- opening of a new market (the market, for which a branch of the industry was not yet represented),
- acquiring new sources of supply of raw material or semi-finished goods,
- new industry structure such as the creation or destruction of a monopoly position (Śledzik, 2013).

Innovation is understood in a wide spectrum and is a common symbol for change, something new, expressing itself as new products, innovative technologies, non-traditional services or unconventional management methods (Sikora & Uziębło, 2013). It is also considered as the final stage of the creation of new material reality, the first use of new ideas in practice (Bogdanienko, Haffer & Popławski, 2004). Many theoreticians of management see innovations as a process occurring in the industry, more precisely as the first market introduction (implementation) of a new product, process, system or device, the first usage of an invention (Jasiński, 1997). Some authors treat innovations in a broader sense, stating that it is a sort of creative changes, occurring not only in industry but also in other systems: social, economic, technological, environmental etc. (Marciniak, 2008). Innovation is an act of introducing something new, a new idea, more effective device or process. Some authors claim that the terms "innovation" and "invention" are equated, being defined as a complex developing process of innovation creation, distribution, use, focused on efficiency growth and development of innovative activities (Manuylenko et al., 2015). In the public opinion, innovations are often equated with inventions. However, some authors present a different approach, these are two different concepts. "Invention" can be defined as the creation of a product or introduction of a process for the first time. "Innovation," occurs if someone improves on or makes a significant contribution to an existing product, process or service. The creator of the Schumpeter innovation theory clearly pointed to the existence of differences between the invention and innovation. He emphasised that only a few entrepreneurs were able to see the potential of a given invention and use it for their benefit (Landreth & Colander, 2005).

In the modern economy, innovations are closely connected to entrepreneurship. Innovations are currently the most efficient way for small and medium-sized companies to exist and remain in the market. A company is considered innovative if it creates, absorbs and obtains new products or services as well as those which are characterised by the ability to constantly adapt to changes in their environment. An innovative company constantly generates and realises innovations, gains recognition among customers due to its high level of modernity and competitiveness and possesses the ability to adjust its management methods to a specific task (Sosnowska, Łobejko & Kłopotek, 2000).

According to the Central Statistical Office, in recent years, entrepreneurship in Poland can be characterised by three significant trends. Firstly, over the course of the last few years, the number of companies has been growing dynamically. Every year, 1/3 of a million new companies are created, and this number has been at a similar level for a longer period. Secondly, the quality of the Polish entrepreneurship is improving. Polish companies, as a group, take an increasingly larger part in the building of social welfare. The data shows that they are responsible for an increasingly larger part of the Polish GDP. Tendencies also point towards the improvement of the company structure from the point of view of legal forms. The percentage of companies as legal entities is increasing while that of companies as natural persons is decreasing. Thirdly, there is a growing openness of entrepreneurs and their focus on the development. Polish companies invest increasingly more, and they design and implement innovations, although the scale of developmental activities is still not very large. At the same time, the number of persons working at an individual company is decreasing, which is partly connected to the numbers of new small companies. Unfortunately, one of the visible tendencies is also the decreasing percentage of innovators (Polish Agency for Enterprise Development, 2017). Despite this, expenditure on innovative activities is increasing, although this is a tendency visible mainly in industrial companies.

Since a few years, startups are being mentioned in the context of innovation as a new phenomenon which are being treated as a development motor for the economy. A startup is a new company, with no experience or knowledge, which begins to use the opportunities entering new areas. It can be stated that it is a specific period in the life of a company, a very difficult period, during which the company is fighting for its survival. Recent OECD work has shown that new and young firms contribute disproportionately to job creation. Startups may also be more effective in exploiting new technologies, which can help address some of the major policy challenges of our times (e.g., climate change, aging society). Innovative startups can also be instrumental in achieving more inclusive societies by promoting social mobility. However, countries and regions, differ significantly in the degree to which innovative businesses are created and prosper (Breschi et al., 2018).

Currently, creating startups is a global trend. Many cities and countries continue to seek better ways to create a strong environment for startups. Global Startup Ecosystem Report and Ranking 2017 is based on a year's worth of research, spanning a whopping 10 000 startups and 300 partner companies. Startup Genome assessed 55 startup ecosystems across 28 countries. The report was made as result of speaking with entrepreneurs and massive amounts of data on startups. It examined how cities help to grow and sustain startup ecosystems through eight major factors: funding, market reach, global connectedness, technical talent, startup experience, resource attraction, corporate involvement, founder ambition and strategy. Among the top 20 startup ecosystems, nine are located in North America, six in Europe, with the remaining five in Asia. The role of Asian startups is increasing. Beijing and Shanghai appeared on the map of significant startup ecosystems. Unfortunately, Polish startups do not play a significant role in this global ranking so far (Startup Genome, 2017). However, Poland is becoming attractive due to the low cost of hiring software developers, good location and low office rents in large cities, compared to other European countries.

There are many definitions of startups, such as using the term to refer to an enterprise in which the processing of information and derivative technologies are key elements of the business model. The definition of a startup will, however, be different for enterprises in the initial stages of development and those which already are mature enterprises. Often startups, after finding their business model, transform into other organisations, e.g. micro-enterprises or corporations. Others remain as startups for a longer period, operating in a non-stable and uncertain market environment (Skala, Kruczkowska & Olczak, 2015; Magruk, 2017). A startup is not just a small company; it is an economic entity with slightly different needs. Startup ecosystems can be related to features of their national economies. It also affects the differences between startups in different parts of the world. Studies of start-up ecosystems need to consider their regional institutional and cultural context (Hemmert et al., 2016). There are various approaches to the issue of how long a functioning enterprise can be referred to as a startup. Some say that a startup is an enterprise created to create new products and services under the conditions of high insecurity, with a history no longer than ten years (Deloitte, 2016). The experiences of the most developed economies suggest that the development of such enterprises requires an efficiently functioning environment, referred to as an ecosystem. These young companies can face many challenges, such as legal regulations being a development barrier, or financial issues when the company cannot obtain financial support in the form of a loan in its initial phase of development. However, the understanding of the intellectual potential of a given company is also extremely important. In Poland, there is still low understanding of intellectual property, which can lead to the use of exclusive rights of others. Modern companies frequently have to pay attention to the necessity of protecting their intellectual property created by their employees and the knowledge they have accumulated. This necessity results from the fact that intangible assets including innovations and new technologies have become more significant, throughout the years, in the development of companies and creating a competitive edge. The protection of intellectual property should become one of the elements of the strategy of companies. However, it is not always so, and entrepreneurs including startups are not always aware of the importance of this issue.

2. Discussion of the results

2.1. The importance of intellectual property protection in an enterprise

The matter of innovation is the main concern of any startup. Startups may face difficulties in developing certain product or service without the protection of innovation since competitors can easily steal one's idea if they know it is not well protected. Therefore, every startup should not underestimate the value of Intellectual Property Protection and be aware of how to deal with it. Intellectual property is important at every stage of business development. Many small businesses or young entrepreneurs do not understand various types of intellectual property and the protection that can be ensured for their products and services.

The basic condition which enables technological development is a modern, efficient and effective system for the protection of intangible assets. The ownership of rights to use inventions, technologies, designs or various trademarks is gaining more significance for the functioning of businesses. One of the most valuable assets of a modern business is a known and appreciated trademark, product name or packaging design. These elements create the market identity of a company and often determine the ability to generate profit. Also, the rights to use the created or purchased technology, construction solutions, created inventions or industrial designs have a significant influence on the value and market standing of a company and the perspectives for its further development. Another crucial issue is the company's confidentiality, which can be of strategic significance for its development. In the case of startups, the first important element of intangible resources is the idea for a new business itself, the knowledge regarding the chosen business profile, which can be a strategic resource.

In 2016, the Startup Poland foundation conducted surveys among Polish startups, which showed the condition of such companies. These entities were still young; their average age was under two years. This has put them in the third place in Europe with the youngest business, right after Romania (1.3 years) and Italy (1.7 years). There were very few foreigners working in Polish startups. 95 per cent of innovative companies were founded by Poles, and only five per cent of their employees were foreign nationals. Polish startups mainly developed software and services for mobile devices and focused on e-commerce. The level of patent activity in general among Polish enterprises was very low compared to European and world leaders. However, in startups created after 2015, the awareness of patent protection has been growing. Every fourth startup collaborated with a university, and a similar number worked with an individual researcher. Every tenth surveyed startup had its research laboratory. The survey shows that startups have insufficient knowledge regarding the means of protecting their inventions as well as the benefits of obtaining such protection. The low interest of Polish companies in applying for a patent is mainly due to barriers in cooperation between science and business. There are differences in the perception of the value of technology, problems with the transfer of rights and developing solutions in research and development units that are often divorced from the needs of the market (Skala & Kruczkowska, 2016). Sometimes, start-uppers are concerned with the product or software development, taking care of the innovation. They do not think about registering the trademark, buying patent or acquiring trade secrets (Harroch, 2017). Patent applications are definitely not the end goal of a startup, they usually represent a stepping stone in the firm's development and can be seen as an indicator of success in acquisitions for firms that are not yet mature. It is recognised in the literature that startups that hold patents experience higher growth in terms of employment and sales (Farre-Mensa et al., 2015). Mann and Sager also claimed that for the great majority of startups the possibility of patenting is somewhat low on the list of investment criteria and the decision to patent is a routine rather than a strategic one. Startup firms for which patents are useful obtain patents in due course if the firm survives long enough for the patents to become valuable. Startups must account not only for the possibility that patents might impose substantial costs but also for the possibility that they provide substantial benefits (Mann & Sager, 2007). Literature and reports indicate that the approach to intellectual property protection in startups is similar in most countries around the world. However, differences may result from different legal systems. The most specific situation is in the United States due to the dominant patent activity of large corporations. The literature on patent systems portrays small inventors, including startups, as suffering the most from the shortcomings of the patent system. This is connected with applying for patents, enforcing their patent rights, and defending themselves when sued by larger rivals. A chief criticism of the U.S. patent system is that it takes too long to approve or reject patent applications (Farre-Mensa et al., 2015). In some countries, the average time to grant from application now stands at ten years or more. For example, in Thailand, the average pharmaceutical patent granted in 2015 was 16 years old. In Brazil, patents in mobile technology fields are averaging more than 14 years old (Schultz & Madigan, 2016). In Poland, the average time to grant from application stands at five years. Such a long waiting time is unhelpful for most inventors, businesses, and technology investors.

In the last decade, the approach of Asian countries to the protection of intellectual property has clearly changed. Before 1985, China had no patent law at all. The approach of Asian corporations to IP management has evolved in the past few years. Many companies are embracing global best practices in the field of intellectual property protection. Licensing and litigation are increasing across the region because companies are aware that having a high-quality IP portfolio is the key to staying competitive worldwide (Taylor, 2018).

Criticism of patent systems around the world has been rife in the last few years. The main problems are connected to lengthy waiting for a patent, high protection costs and complicated intellectual property regulations. Regardless of the disadvantages of this system, this is the best way to protect ideas and innovations.

2.2. Lack of the intellectual property management strategy in startups

Effective management of intellectual property should be one of the basic elements of the company's development policy, which may significantly influence its increase in competitiveness in the market. Management of intellectual property in a company consists of the development of intellectual property, market analysis, protection of intellectual property rights, actions aimed at commercialisation, sharing the know-how and selling of the rights in possession (Truskolaski, 2014). The strategy of managing intellectual property should be a part of the general development strategy of a company. It should be individualised, related to the specific goals of the company, its size and business profile, which could influence the necessity to increase the focus on a specific type of protection of individual intangible assets. Complex innovation settings require firms' IP strategies to include protection and/or sharing of their own technologies on the one hand and access to others' technologies on the other hand (Holgersson et al., 2018). The fact is that the complex nature of intellectual property rights can have an impact on the creation of a startup strategy. However, some legal forms of protection of intangible goods are not known at all. The knowledge about the protection of intellectual property in enterprises is rather low.

In Poland, 34% of entrepreneurs do not have an innovative strategy and do not foresee its implementation in the near future. 33% of companies declare that this strategy will be developed in the future. Only 18% of enterprises have such a strategy. A common reason for the implementation of the innovation strategy is the emergence of new technology or customer needs. Enterprises that have innovative strategies are usually business entities with a strong market position (Tarnawa, 2016).

Strategy for startups should chiefly include high economic and innovation risk, which is characteristic of such companies. The choice of the strategy is dictated by the specificity of the company, its business, institutional and market positioning. The company can choose an active strategy, passive strategy or entirely ignore the existence of intellectual assets and their economic significance. Larger companies can allow themselves to choose an active strategy because they possess greater financial resources and most possibly already play a significant role in the market. A young company will select a passive strategy, spending smaller amounts of money on the development and protection of intellectual resources. However, is this method of approaching the protection of intellectual resources appropriate for startups? A startup can choose an active strategy, as a subject, whose business activity is closely related to a specific innovation, it must decide regarding the method of protecting its innovation (Kasprzycki et al., 2008). Naturally, the cost of obtaining patents, especially in the European or international procedure means large expenses, but such a patent should protect the basic technology of a company and its competitive advantage, ensure income from licensing, or make the company more attractive for buyers or investors. Due to the financial limitations of startups they can also opt for choosing unpaid intellectual property protection, protecting their intangible assets through company confidentiality and copyrights. As startups often operate in the field of IT, it is often thought that since software is not subject to patents, the issue of property protection does not apply in this case. In Poland, the protection of software is managed through copyrights and is protected in the same way as literary works. Such protection does not require registration or financial expenses, although the process of creating software to account for protection and co-authorship is relatively complex; therefore, specialist knowledge is required to be able to effectively use own exclusive rights. The trademark, which is visible on products, and the industrial design need to be kept in mind as important for every company. The protection of these intangible assets should also be taken into consideration. A startup company can decide to choose a two-tier strategy, i.e. choose more expensive but most efficient patent protection for a strategic product and maintain company confidentiality and protection of copyrights where possible. The OECD report shows that patent applications for startups are positively connected with the probability of obtaining funding for their development (Breschi et al., 2018).

There are still debates in the literature on whether the propensity rate to patenting increases with firm size. Some authors claim that firm size has a positive relationship with intellectual property management. Some studies report that small firms tend to file a patent more frequently than larger ones. In the U.S., large firms tend to use their own tools and decision criteria to determine how they strategically manage IP, while small businesses tend not to use a formal strategy (Cho, Kirkewoog & Tugrul, 2018).

At the initial stage, startups require the support of a strategic partner, who can invest in the project, but also share their experience. In this context, it is important to remember undertaking actions to protect the knowledge or the idea which is in possession of the startup before it shares this idea with other subjects. The exchange of know-how should be protected by an appropriate confidentiality agreement. The use of such agreements and monitoring of intellectual property databases should be a key element for the economic development of startups. The identification of the activities of competitors, which is related to the creation of innovative technologies, should be a basic element of every company's operations. In the case of startups, this seems to be a necessity even at the stage of an idea for a business (Coalition for Polish Innovation, 2015).

The prevention of the infringement of exclusive rights owned by the company and third parties should be considered as a part of the intellectual property management strategy. Polish companies can easily obtain information on the granted and binding ownership rights of industrial property in the country, as the Polish Patent Office maintains a database of all industrial ownership rights granted by this office. Many patent databases and international reports are available as well. The monitoring of patent activities of competitors should also be included in the IP protection strategy of a company.

2.3. Financial challenges of startups

For a long time, the basic problem with the development of innovations in Poland was the lack of a proper financing system of such enterprises. In the case of Polish companies, the problem lies in the lack of own as well as external financing sources, especially for new, innovative and risky enterprises, mostly in the research stage and in all fulfilment stages (Wiśniewska & Janasz, 2015). The most popular financing source for Polish startups in the initial phase of development is own resources, the European Union grants and venture capital (VC) funds (Skala & Kruczkowska, 2016). The source of external capital is venture capital (domestic or foreign), followed by public financing available from the European Union funding (via PARP (Polish Agency for Enterprise Development) or NCBiR (National Centre for Research and Development)). Slightly fewer startups use capital obtained from acceleration programmes (Beauchamp, Kowalczyk & Skala, 2017). The main source of financing for startups in Europe is also the savings of the creators, financial resources obtained from friends or family and government grants or funds. Alternative financing sources are available, such as business angels or venture capital. Unfortunately, in Poland, the market for such financial support is very poorly developed (Cegielska & Zawadzka, 2018). The high risk of an innovative enterprise and difficulties in the assessment of the potential of a given enterprise curb the enthusiasm of private investors. However, some positive changes can be seen, as in 2017, more startups have benefited from investments of a private business angel or a venture capital fund than from the European Union resources (Biskupski, 2017). VC firms can provide capital, strategic assistance, introductions to potential customers, partners, and employees. Comparing the innovation ecosystems of the EU and the US, there is a difference in the amount of venture capital available. In 2016, venture capitalists invested about EUR 6.5 billion in the EU compared to EUR 39.4 billion in the US. Europe's venture capital funds are not big enough to attract major institutional and private investors. Another problem is the source of the VC funding: compared to the US, the EU venture capital receives far more public funding and much less private investment (VentureEU, 2018). The difference between the US and European startups is that European entrepreneurs find it easier to raise initial capital, while US startups have better access to later-stage capital. There is no real single digital market in Europe. In the US or China, tech entrepreneurs gain immediate access to a massive market. In Europe, they still must navigate 28 different markets and regulatory regimes (Echiksone, 2017).

The protection of intellectual property is still rather expensive nowadays. The costs include mainly the designing and implementation of a management strategy regarding industrial property protection, the costs of legal services related with obtaining exclusive rights, administration fees, costs of legal disputes, in and out of court (e.g. arbitration). Of all the available forms of protection, patent protection is the most expensive. As protection solely by a national patent makes no sense, the obtaining of a European patent or a patent in a multinational procedure needs to be considered, this being a very expensive procedure, which can be very discouraging and problematic for startups.

In 2017, in Poland, the PFR Ventures (Polish Development Fund) platform launched, which is comprised of five venture capital investment funds. The aim of this platform is the development of innovative companies through financial and expert support. The development of startups will receive EUR 700 million by 2023. The fund targets the development of small and medium-sized Polish innovative companies in their earliest (pre-seed) and initial (seed) stages of development. The result is expected to be a considerable improvement in access to financial means for innovative companies, attracting foreign capital, and buoying the domestic investment market (Beauchamp et al., 2017).

However, it seems that the issue of financing startups may not be the most important one as an increasing amount of money is becoming available for innovations in the market. A greater problem can be the support at the level of creating a business model, its adjustment to the business conditions within the country, as well as designing a development strategy, including the protection of intellectual property.

Conclusions

Startups became a worldwide trend during the last decade all over the world. The number of people wanting to set up a business without or with minimum resources is rapidly increasing. The largest investments in IT and technology firms were mainly in the United States. Currently, the European market, as well as the Asian market is catching up fast.

Intellectual property represents an important financial and legal asset for companies, including startups. Intellectual property protects whatever value there is in the company (brands, inventions, design), and also contributes to its increase. Appropriate protection of intellectual property owned or used allows to gain competitive advantage, become recognisable, build reliability and reputation. For investors, startups with a solid intellectual property portfolio are attractive investment targets.

Management of intellectual property is a set of intertwined activities subordinate to major business goals of an enterprise. These activities cover identifying, acquiring, protecting, using and disposing of intellectual property assets and analysing applicability.

Startups face many challenges on their way to becoming a successful company. Even though the support for innovation has increased rapidly during the last decade and tends to grow even more by 2020, especially in the European Union, startups are still facing high fluctuations and competition in the market. The role of startups as contributors to economy is getting larger. However, these companies are still facing many problems. One of the most demanding and hardly implementable of them is the Intellectual Property Protection.

New enterprises have to decide on the intellectual property management strategies, and this strategy is recommended to be active. On the one hand, this way of protection can be costly and demanding. On the other hand, a patent should protect the company's basic technology and competitive advantage, provide licensing income or make the company attractive to buyers and investors. Due to the financial limitations of startups, they may opt for unpaid protection, protecting their intangible assets with business secrets and copyrights.

What seems to be the most difficult for startups are the financial issues, since there are always limited resources that a company possesses. As it was mentioned previously, new entities can choose the way of protection from among many available types. A patent is among the most expensive choices. Despite its high cost, it is also considered to be one of the safest solutions. Since protection only through the national patent does not make sense, one should consider obtaining a European Patent or an international procedure, which, however, is a very expensive procedure, very problematic for new entrepreneurs and may discourage startups from making this financial effort.

To sum up, the role of the Intellectual Property Protection in startups can be considered as one the most crucial in today's highly competitive business environment. To survive in such environment, newly based businesses have to manage intellectual property effectively.

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