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GEODESY AND CARTOGRAPHY
Vol. 65, No 1, 2016, pp. 111-122

DOI: 10.1515/geocart-2016-0005

On the use of IT investment assessment methods in the area of spatial data infrastructure

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Received: 5 October 2015 / Accepted: 20 November 2015

Abstract: One of the important issues concerning development of spatial data infrastructures (SDIs) is the carrying out of economic and financial analysis. It is essential to determine expenses and also assess effects resulting from the development and use of infrastructures. Costs and benefits assessment could be associated with assessment of the infrastructure effectiveness and efficiency as well as the infrastructure value, understood as the infrastructure impact on economic aspects of an organisational performance, both of an organisation which realises an SDI project and all users of the infrastructure. The aim of this paper is an overview of various assessment methods of investment as well as an analysis of different types of costs and benefits used for information technology (IT) projects. Based on the literature, the analysis of the examples of the use of these methods in the area of spatial data infrastructures is also presented. Furthermore, the issues of SDI projects and investments are outlined. The results of the analysis indicate usefulness of the financial methods from different fields of management in the area of SDI building, development and use. The author proposes, in addition to the financial methods, the adaptation of the various techniques used for IT investments and their development, taking into consideration the SDI specificity for the purpose of assessment of different types of costs and benefits and integration of financial aspects with non-financial ones. Among the challenges are identification and quantification of costs and benefits, as well as establishing measures which would fit the characteristics of the SDI project and artefacts resulting from the project realisation. Moreover, aspects of subjectivity and variability in time should be taken into account as the consequences of definite goals and policies as well as business context of organisation undertaking the project or using its artefacts and also investors.

Keywords: assessment method, spatial data infrastructure (SDI) business project, costs, benefits

1. Introduction

One of the important issues concerning development of spatial data infrastructures (SDIs) is the carrying out of economic and financial analysis. It is essential to determine expenses and also assess effects resulting from the development and use of infrastructures. Costs and benefits assessment could be associated with assessment of the infrastructure effectiveness and efficiency as well as the infrastructure value, understood as the infrastructure impact on economic aspects of an organisational performance, both of an organisation which realises an SDI project and all users of the infrastructure. Results of the economic and financial analysis (Dudycz and Dyczkowski, 2007) also have an impact on decisions made by project managers and vary according to the time of conducting the assessment. In the initial phase of a project, economic and financial analysis allows for decisions to be made about starting up the project and choosing the best variant to be carried out. During the infrastructure implementation, the analysis allows for improvements to be made in the project, as well as drawing up of a balance sheet after closure of the SDI project and preparation of recommendations on optimisation of the following projects.

In the context of building Infrastructure for Spatial Information in the European Community (INSPIRE), the necessity of conducting the economic and financial analysis indicates INSPIRE directive (2007/2/EC). The directive states the obligation of costs and benefits assessment in implementing Directive (2007/2/EC, Art. 21(2) e). Moreover, with reference to the INSPIRE directive and the issue of benefits, Commission decision (2009/442/EC) in Art. 16 indicates in general terms the need to present examples of the benefits observed, including examples of the positive effects on policy preparation, implementation, evaluation, examples of improved services to the citizen as well as examples of cross-border cooperation.

The aim of the paper is an overview of various assessment methods of investments as well as an analysis of different types of costs and benefits used for IT projects. Based on the literature, the analysis of the examples of the use of these methods in the area of spatial data infrastructures is also presented. Furthermore, the objective is also a broad outline of SDI projects and investments issues.

The contribution of this paper is the compilation of assessment methods deriving from the field of IT investments which could be used in the area of SDI. The examples presented in this article indicate that not only financial methods are essential, but also qualitative and descriptive ones. The author proposes in addition to the financial methods the adaptation of the various techniques used for IT investments and their development taking into consideration the SDI specificity for the purpose of assessment of different types of costs and benefits as well as integration of financial aspects with non-financial ones.

This article is structured as follows. Sections 2 and 3 give brief outlines of an SDI project and investment as well as financial and economic analysis. The analysis's results concerning costs and benefits assessment methods of IT investments as well as an overview of the examples of the use of these methods in the area of the SDI

are described in Section 4. Section 5 discusses the results. Section 7 closes the paper with conclusions.

2. SDI business project

Projects are taken up to realise a specific product or service. The uniqueness of projects is manifested in a variety of needs satisfied by every project and the different business context of enterprises. Every project is temporary – it has a definite beginning and a definite end, and is constrained by limited resources. Projects are undertaken at all levels of the organisation, but they may also cross organisational boundaries and are planned, executed, managed and controlled by flexible organisational structures. Moreover, projects have considerable autonomy and specified boundaries, and therefore fall outside the organisation's normal operational activities.

An information technology (IT) project is a temporary endeavour which purpose is design, implementation and installation of artefacts such as: computers, storage, networking and other physical devices, as well as databases and processes.

Murphy (2002) describes the concept of the business context on which every IT project is based. It should be noted that the business context is continually changed by drivers of business change. The analysis of the business context of the organisation includes the stakeholders' identification and their requirements, organisational goals, but also the relations and interactions between the stakeholders.

To build or develop spatial data infrastructure IT projects are taken up. These projects allow to implement the SDI components (e.g. datasets, metadata, network services, software, hardware). Also essential in this perspective is (Zwirowicz-Rutkowska, 2014) the business context and objectives of an organisation and investors who are planning an SDI project, have a project in progress or have just completed one. For SDI, the drivers of business change are e.g. e-Government, globalisation, technological change, laws and update of the laws. The organisations and investors implementing an SDI are mainly authorities. But business context and objectives are important to authorities the same as to private entities. Therefore, an SDI business project should be considered as the sum of IT elements to be designed, implemented, and installed, a whole IT lifecycle (i.e. the plan phase, the deliver phase, the operate phase, the manage layer) and the business objectives. The general formula for the SDI business project is as follows:

$$SDI = X \{D, S, O, U, P, S, H, N, B\}$$

where:
D – datasets, datasets series, metadata, databases; S – network services; O – operators, administrators; U – users ; P – processes, standards, procedures, legislation, SDI policies and goals; S – software; H – hardware; N – computer networks; B – business context and objectives of an organisation and investors implementing an SDI

Figure 1 presents the UML class diagram of the IT projects' typology based on Remenyi, Money and Sherwood-Smith (2000), as well as Lech (2005), which could be referred to the area of the SDI. Classification criteria are: purpose, scope, complexity, change dimension and resources. Fragmentary projects involve a single position or unit and are concerned with selected activities and not with the whole processes (in contrast to task projects). If a project involves a selected unit or cross-functional areas, it is a thematic one. The integrated projects involve many different business processes. The organisation's resources are mainly used for simple projects of small IT products' modifications or improvements. The mixed resources projects are large-scale, long-time and complex. Projects result in new products or services, but also have an influence on organisational structure changes, business process reengineering and technology (e.g. hardware, software). If the investment is a must-do – which means that it is either required by law or is an industry standard, then the main strategic goal behind it is clear and fixed: 'staying on board'. The business improvement projects are undertaken to achieve operational business goals, and the competitive advantage projects to achieve strategic business goals. If the project has the purpose of increasing the technical capacity, then the achievement of the functional goals (technical specification) will be the main success.

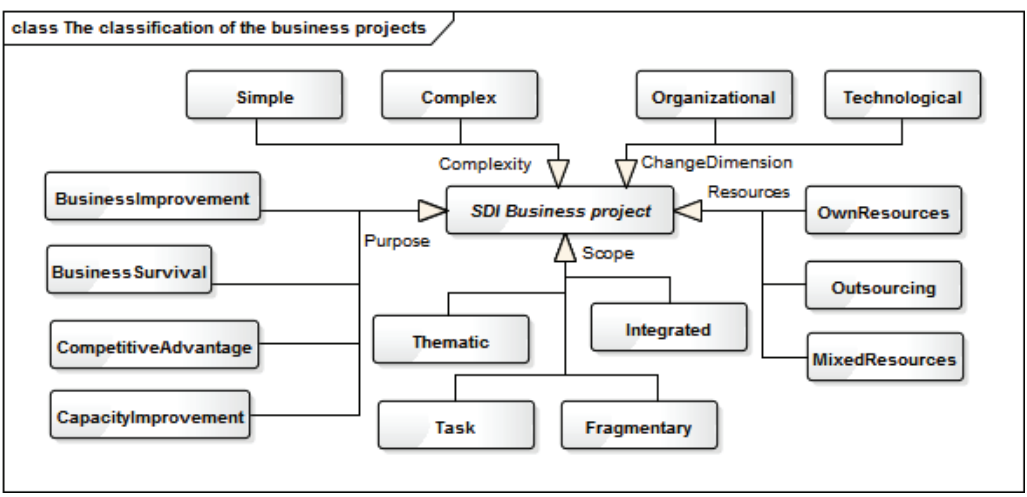

Fig.1. Typology of SDI business projects

3. Financial and economic analysis

In general, financial analysis is (Investopedia, 2015) the process of evaluating businesses, projects, budgets and other finance-related entities to determine their suitability for investment. Typically, financial analysis is used to analyse whether an entity is stable, or profitable enough to be invested in. When looking at a specific

company, the financial analyst will often focus on the income statement, balance sheet, and cash flow statement. In addition, one key area of financial analysis involves extrapolating the company's past performance into an estimate of the company's future performance.

In the area of the European Union funds (European Commission, 2008; 2014) the guides for investments projects indicate that the main purpose of financial analysis is to use the project cash flow forecasts to calculate suitable net return indicators. They also present goals of financial analysis such as: (1) assessing the consolidated project profitability, (2) assessing the project profitability for the project owner and some key stakeholders, (3) verifying the project financial sustainability, a key feasibility condition for any typology of project, (4) outlining the cash flows which underpin the calculation of the socio-economic costs and benefits.

Economic analysis is (Businessdictionary.com, 2015) a systematic approach to determining the optimum use of scarce resources, involving comparison of two or more alternatives in achieving a specific objective under the given assumptions and constraints. Economic analysis takes into account the opportunity costs of resources employed and attempts to measure in monetary terms the private and social costs and benefits of a project to the community or economy.

The EU guidelines for investment projects (European Commission, 2008; 2014) state that the economic analysis appraises the project's contribution to the economic welfare of the region or country. It is conducted on behalf of the whole of society instead of just the owners of the infrastructure, as in the financial analysis. The key concept is the use of accounting shadow prices, based on the social opportunity cost, instead of observed distorted prices. Observed prices of inputs and outputs may not mirror their social value (i.e. their social opportunity cost) because some markets are socially inefficient or do not exist at all. When market prices do not reflect the social opportunity cost of inputs and outputs, the usual approach is to convert them into accounting prices using appropriate conversion factors, if available from the planning authority. In other cases, there may be project costs and benefits for which market values are not available. For example, there might be impacts, such as environmental, social or health effects, without a market price but which are still significant in achieving the project's objective and thus need to be evaluated and included in the project appraisal.

4. Benefits and costs assessment of SDI investments

This section presents the results of the analysis of IT investments evaluation methods as well as costs and benefits types, which could be considered for SDI business projects.

4.1 Assessment methods of IT investments' costs and benefits

Among the criteria of the IT investment impact on an organisation's bottom line, tangible and intangible benefits are distinguished. A tangible benefit can be defined as (Murphy, 2002) one that directly impacts an enterprise's bottom line, such as a direct cost savings or revenue generation. An intangible benefit is one that brings about improvement in performance, but not in a way that directly impacts the bottom line.

A direct cost is an expense that can be traced directly to (or identified with) a specific cost object such as a process or product. An indirect cost is any cost not directly identified with a single, final cost objective, but identified with two or more final cost objectives or an intermediate cost objective.

If costs/benefits can be measured, they are quantitative, otherwise they are qualitative. Quantitative costs and benefits are expressed either in a monetary unit (financial costs and benefits) or a physical one (non-financial costs and benefits). Assessment of the financial and non-financial costs and benefits requires different performance metrics, weighting, ranking and scoring schemes. For the qualitative contribution verbal description is used, as well as some multi-criteria and strategic analysis methods.

Benefit and cost tangibility and measurability certainly affect the method with which they should be evaluated (Remenyi and Sherwood-Smith, 1997). The literature on management information systems confirms that there is a multiplicity of evaluation approaches available, each with its own characteristics and focus (e.g. Farbey et al. 1992; Lech, 2005; Remenyi et al. 2000).

Table 1 presents the results of IT investments evaluation method analysis, as well as costs and benefits types, which could be considered for SDI business projects. Costs and benefits classification is particularly essential in perception of evaluation of SDI effectiveness and efficiency as well as value at various levels.

Table 1. The analysis of the assessment methods of IT investments' costs and benefits

Costs and benefits type	Methods (examples)
Quantitative, direct and indirect costs; tangible benefits, Financial	Return on Investment (ROI), Net Present Value (NPV), Internal Rate of Return (IRR), Total Costs of Ownership (TCO), Total Benefits of Ownership (TBO), Return on Management (ROM), Expected Value of Information (EVI)
Quantitative, direct and indirect costs; tangible and intangible benefits, Non-financial, financial	Multi-criteria methods: e.g. the five pillars of benefits realisation; Strategic analysis methods: e.g. Balanced Scorecard (BSC), Information Technology Scorecard (ITSC)
Qualitative	Verbal description; multi-criteria methods; strategic analysis methods

4.2 Overview of methods used for SDI

An issue of SDI assessment is broadly discussed in the literature as it plays an important role in the SDI management tasks. Many different methodologies and techniques are considered for SDIs (e.g. Giff and Crompvoets, 2008; Grus et al., 2011; Vandenbroucke, et al., 2013; Macharis and Crompvoets, 2014). To structure and organise SDI evaluation a concept of SDI assessment framework is introduced (Grus et al., 2007) which integrates approaches to assessing particular SDIs from certain viewpoints.

This section presents the overview of the use of the assessment methods in the area of SDI, which derive from various fields of management, as well as IT investment (Table 1).

Cragila and Nowak (2006) indicate that in the area of SDI, different terms could be used, including economic measures, e.g. social impact, environmental impact and social cost benefit analysis (CBA) as well as financial ones (ROI, IRR, NPV). Moreover, they state that the choice of tool depends on the focus of the assessment, but also on time and resources available. For the purpose of costs and benefits identification and quantification references to the e-Government Economic Programme (eGEP) and NASA studies are made in the paper. Geudens et al. (2009) introduce a methodology for assessing SDI strategies called multi-actor multi-criteria analysis (MAMCA). This technique is an extension of the multi-criteria analysis (MCA) and allows for structured and extensive stakeholder participation during the entire evaluation procedure. The methodology provides a new assessment framework that takes into account all the different criteria and actors of the complex SDI decision making context. The case study of policy strategies for the SDI in Flanders is presented. As all multi-criteria methods, MAMCA also establishes various scores and indicators which are both quantitative and qualitative. The application of this method is valuable in the search for, and assessment of, new SDI policy strategies.

Craglia and Campagna (2010) identify and quantify costs and benefits of the SDI implementation. Deliberations are based on a theoretical framework on the expected benefits of investments in e-government (eGEP). On the costs side, the main categories are a result of the 2006 workshop (Craglia and Novak, 2006), and the review of the literature focused on technology and processes. Benefits are classified into three groups of impacts: efficiency, effectiveness and democracy. For each benefit category a set of indicators both qualitative and quantitative is proposed. Some direct costs for these studies as well as benefits in a monetary unit and physical one are quoted by authors. However, no detailed information about assessment methods used for this purpose is mentioned in the paper. Moreover, the authors indicate that it is possible to measure tangible economic benefits, as well as less tangible but important social benefits of the investment made in SDIs, although this requires detailed studies which take time. The issue of costs and benefits of the SDI implementation is also discussed by Bregt (2012). He uses cost-benefit analysis for the INSPIRE implementation. An ex-post assessment of benefits of the SDI investment is developed by Borzacchiello

and Craglia (2013). The authors present the methodology to estimate benefits deriving from the usage of e-Government services.

Toomanian at el. (2011) proposes a balanced scorecard as a framework for evaluation and monitoring the implementation of SDIs. The case study is the Swedish NSDI at the national level. The paper explains how BSC can assist SDI managers and coordinators to evaluate the degree of success of an SDI both from a producers' perspective by assessing the organizations involved, and from the users' perspective by analysing their expectations about use of spatial products.

5. Discussion

Results presented in sections 2-4 allow for the compilation of issues concerning SDI investments and approaches of conducting economic and financial analysis which derive from various fields of management, as well as information and communication technology (ICT). The listing (Table 1) and the examples described in Section 4.2 indicate that in the area of SDI assessment various methods could be used, including financial tools, and also other types of quantitative techniques as well as qualitative ones. However, generally as it is indicated by Shuurman et al. (2009) and Irani et al. (2006) the emphasis in information system (IS) benefits research lies heavily on non-financial aspects and research on costs has rather a dominant financial orientation in IS literature.

Financial methods, based on tools of financial analysis (e.g. ROI, NPV, IRR from Table 1), are the most desirable from the investors' perspective, but include only selected costs and benefits which are defined in the monetary unit. They are considered for SDI projects (e.g. Cragila and Nowak, 2006; Bregt, 2012; Borzacchiello and Craglia, 2013), although as literature overview shows many of available deterministic and non-deterministic models are not much explored and used in the area of SDIs.

Methods dedicated to IT investments such as (Table 1) TCO, ROM, EVI, ITSC, the five pillars of benefits realisation are appropriate for the geospatial infrastructure because IS and SDI have much in common. Among shared features (Section 2; Tańska 2003) are the following: software, hardware, users and operators, documentation and procedures, as well as databases. However, the specificity and other components of the infrastructure, expressed in terms of the general formula in Section 2, should be also taken into consideration (e.g. in case of TCO method and the INSPIRE directive the processes of data interoperability and harmonisation, or monitoring and reporting should be included for P – processes, procedures & SDI policies and goals).

Costs and benefits identification and also quantification as well as establishing measures which would fit the characteristics of the SDI project and artefacts resulting from the project realisation are essential issues in the area of SDI assessment. Some proposals for the geoinformation infrastructures which refer to the expected benefits

of investments in e-government and on the costs side to technology and processes are presented by Craglia and Campagna (2010). The author of this paper suggests considering the costs and benefits categories used in IT investments such as (Table 1) TCO or TBO.

Bregt (2012) underlines that on the one hand cost-benefit analysis is easy to understand as it translates all aspects into monetary terms, but on the other hand it is not the right tool for a complex project as INSPIRE, especially during the phase of the infrastructure implementation. In this paper it is indicated that qualitative methods are an interesting option which allows for the integration of financial aspects with non-financial ones. Moreover, Table 1 presents methods which can be used for SDI projects of different size and includes methods suitable for both ex-ante and ex-post assessment, as well as for the purpose of the infrastructure monitoring.

A new multi-criteria method dedicated to SDI is presented by Geudens et al., 2009. As the authors report, their method allows for the assessment of new SDI policy strategies. In the category of strategic analysis methods there is evidence of use the BSC method (Table 1) for the SDI in the literature (Toomanian at el., 2011). Generally, BSC is the universal method for assessment of the organisational effects. This method is (Lech, 2005) thus partially IT-oriented, suitable for evaluating a single project and all of the IT in the organisation, but it concentrates only on one aspect of IT impact on the organisation – supporting the strategic goals. For the purpose of SDIs it is also worth considering multi-criteria and strategic analysis methods which are IT-oriented (ITSC, the five pillars of benefits).

Moreover, aspects of subjectivity and variability in time should be taken into account as the consequences of definite goals and policies as well as the business context of an organisation undertaking the project or using its artefacts and also investors. For example INSPIRE legislation underlines the need of assessing effects which concern policy preparation that may have a direct or indirect impact on the environment or cross-border cooperation. From the national perspective SDI projects are often included in selected programmes of the civil service at all levels, therefore additional requirements could be defined and additional categories of costs and benefits would appear as well as needs for new measures.

The SDI projects are standalone or often parts of bigger investments realised by national or regional authorities which are financed by the European Union funds. The European guides for investments projects (European Commission, 2008; 2014) place a particular emphasis on two financial indicators: NPV and IRR. The guides include analysis of projects by different sectors. The SDI as a specific kind of infrastructure does not match exactly any of the case studies presented in the guides. Rather, it draws extensively on case studies, e.g. of broadband and development infrastructures. In the area of economic analysis, both financial costs and benefits as well as descriptive ones could be considered. There is also possibility of assessing positive effects (e.g. health, environmental) of the project realisation. However, this approach requires further studies on relations between results of the project and outcomes.

Selecting appropriate methods depends on many factors such as (Cragila and Nowak, 2006) a focus of the assessment, time and resources available. For the INSPIRE purpose no specific methods are indicated, according to the classification presented in this paper, although based on the INSPIRE regulations (2007/2/EC; 2009/442/EC) two of them are in use. One method is a verbal description of benefits used for member state reports and the other one is a multi-criteria tool dedicated to monitoring of SDI implementation at national level which is concentrated on the outputs of the SDI. For projects financed by the European Union funds, the guides describe methods which were mentioned previously in this paper.

6. Conclusion

The objective of the paper was the overview of various assessment methods of IT investments as well as the analysis of different types of costs and benefits used for IT projects. Based on the literature, an overview of the examples of the use of these methods in the area of the spatial data infrastructures was also presented.

The results of the study indicate that financial methods from different fields of management are useful in the area of SDI. The author proposes, in addition to the financial methods, the adaptation of the various techniques used for IT investments and their development, taking into consideration the SDI specificity for the purpose of assessment of different types of costs and benefits and integration of financial aspects with non-financial ones.

Assessment methods dedicated to IT investments are appropriate for the geospatial infrastructure because IT and SDI have much in common. However, the specificity and components of the infrastructure should be also taken into consideration. The SDI components described in this paper in terms of the general formula change as the consequence of e.g. technological change, new goals and policies. They can also be different in various organisation which develop their SDIs or use them as taking into consideration business context and objectives of organisations as well as investors implementing an SDI.

Acknowledgements

The research reported in this paper is supported by the grant No. 528–0309–0882 of Faculty of Geodesy, Geospatial and Civil Engineering, University of Warmia and Mazury in Olsztyn, Poland.

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