CORE
Metadata, citation and similar papers at core.ac.uk
Provided by RepoS

Zeszyty Naukowe UNIWERSYTETU PRZYRODNICZO-HUMANISTYCZNEGO w SIEDLCACH
Seria: Administracja i Zarządzanie
Nr 107 2015

PhD Tomasz Kopczyński
PhD Maciej Brzozowski
Poznan University of Economics,
Department of Strategic Management

Systems thinking in project management: theoretical framework and empirical evidence from Polish companies

Myślenie systemowe w zarządzaniu projektami: model teoretyczny oraz jego weryfikacja na grupie polskich przedsiębiorstw

Abstract: This research examines new directions in project management and systems thinking theory and practice. Relevant literature is synthesized to provide a holistic picture of current knowledge of the topic, highlighting meanings, principles, prerequisites, process and consequences. The major aim of the research is to investigate the nature of systems thinking in project management. The research methodology was divided into two phases: (1) designing a theoretical framework for applying systems thinking into project management; (2) evaluating project management practices of enterprises in Poland, to identify their approaches, actions, methods and problems related to the application of systems thinking in project management. Conducted research has shown that there is a gap in the field of systems thinking in project management, which can be seen in the divergence of expectations of executive management with management practices in this regard.

Keywords: project management, systems thinking, agile project management, approaches to project management, project management methodology

Streszczenie: Przedmiotem opracowania są nowe kierunki badań w zarządzaniu projektami oraz myśleniu sieciowym. Przedstawiono wyniki badań literaturowych ukazujących całościowy przegląd aktualnej wiedzy z przedmiotowego zakresu, wyjaśniając podstawowe pojęcia, reguły, przesłanki, procesy oraz ich konsekwencje. Podstawowym celem opracowania jest określenie istoty myślenia systemowego w zarządzaniu projektami. Postępowanie badawcze podzielono na dwie podstawowe części: (1) zaproponowanie koncepcji teoretycznego modelu wykorzystania myślenia systemowego w zarządzaniu projektami, oraz (2) ocenę praktyki zarządzania projektami w polskich przedsiębiorstwach, ukierunkowaną na identyfikację stosowanego podejścia, działań, metod i problemów związanych z aplikacją myślenia systemowego w zarządzaniu projektami. Przepowadzone badania potwierdziły występowanie luki w stosowaniu myślenia systemowego w zarządzaniu projektami, związanej z rozbieżnością pomiędzy oczekiwaniami naczelnego kierownictwa a praktyką działań kierowniczych.

Słowa kluczowe: zarządzanie projektami, myślenie systemowe, zwinne zarządzanie projektami, podejścia do zarządzania projektami, metodyka zarządzania projektami

Introduction

Project management has been increasingly covered topic in scientific and professional literature on management over the past two decades. However, to

date relatively little has been written about project management and systems thinking. It is assumed in the literature that new conditions which have resulted from the environment, determine the necessity to implement new approaches to project management. Sterman points out that treating problem solving as a routine-like constant process may not lead to desirable results in this reality[1]. The traditional approach to project management which emphasizes planning may translate on the expected results in a limited way. There are hardly any cut-and-dried problems in the dynamic and complex environment of projects, and obviously non-standard problems are harder to solve in a conventional way. Displayed processes have been influencing a further theoretical development of project management and also disseminating new approaches to project management. The problem solving methods based on both systems thinking and competences and adaptive abilities of a team are forming conceptual frames of this approach[2].

This research examines new directions in project management and systems thinking theory and practice. Relevant literature is synthesized to provide a holistic picture of current knowledge of the topic, highlighting meanings, principles, prerequisites, process and consequences.

The major aim of the research is to investigate the nature of systems thinking in project management. The research methodology was divided into two phases: (1) designing a theoretical framework for applying systems thinking into project management; (2) evaluating project management practices of enterprises in Poland, to identify their approaches, actions, methods and problems related to the application of systems thinking in project management.

Systems thinking in project management – a theoretical framework

Recent studies on project management indicate that managers more and more often tend to use systems thinking in project management[3]. This approach refers to the need for transparency and thorough understanding of how the different elements of the system influence the system's efficiency. Here, the fundamental principles are the mechanisms and team members' quality thinking in problem solving, the level of knowledge, adaptive abilities, as well as openness, which increases the teams' capability of detecting faulty solutions.

Traditional practices of project management concentrate on neutralizing the complexity of a project by precise planning and involving more control over a project. These actions can have little impact, since the complexity and dynamics present in a project can impede precise future planning and performing control functions in a destabilized system[4].

[1] J. Sterman, *System dynamics modeling for project management*, „Projects and Profits" 2012 Volume II, p. 43-54.
[2] P. Checkland, *Soft systems methodology: a 30-year retrospective,* [in:] P. Checkland, J. Scholes (eds.), Soft systems methodology in action. Wiley, Chichester 1999, p. A1–A65.
[3] K. Remington, J. Pollack, *Tools for complex projects*, UK Gowerment, Aldershot, Hampshire 2007; T. M. Williams, *Modelling Complex Projects*, Wiley, Chichester 2002; K.T. Yeo, Systems thinking and project management – time to reunite, „*International Journal of Project Management*" 1993, Volume 11(2), p.111–117; K.T. Yeo, C.K. Lim, Sources of information systems failure: a systemic perspective, *Journal of Applied Systems Studies* 2000, Volume 1(2), p. 312-326.
[4] S. Cavaleri, J. Firestone, F. Reed, *Managing project problem - solving patterns*, „*International Journal of Managing Projects"* 2012, Volume 5(1), p. 127-140.

Systems thinking is being perceived as a recommended solution to the problem of multi-project management in modern enterprises in dynamic environments, which results in a shift from the operational approach to project management (single project oriented) in the direction of the strategic importance of projects (project portfolio oriented) in business activity[5].

The starting point of applying systems thinking in project management is an understanding of the problem-solving process. In this context, the problem can be translated as a disruption of the present status quo. To complement this approach one must percept the problem as a circumstance which is identifiable and which organization should eliminate it in order to maintain or return to a state of equilibrium[6]. In such an approach, the main task of project decision-makers is to identify and understand the core of a project problem properly. On the basis of research performed among project managers Cavaleri and others point out that project managers usually used to define problems without determining their real reasons[7]. Such patterns of behaviour might diminish the ability to make effective use of relevant knowledge areas necessary to solve specific problems. The tendency to misinterpret problems and a false determination of the causes of these problems is also strengthened by assigning a problem to an individual, instead of a complex whole. Wrong identification of the problems and their causes has its roots not only in the individual perception of the problem, but also in false assumptions and insufficient knowledge of the problems and their causes in a wide project environment[8].

In the light of these considerations it can be assumed that project management approach based on systems thinking is capable of dealing with problems which exist in complex and dynamic systems, to which modern projects are included. However Apello emphasizes that it requires from the staff a change in the project management approach process and encompass four important areas[9]:

- a holistic approach to problem solving,
- a network of interactions,
- role play scenarios in dynamic and complex systems,
- project team approach based on adaptation and creativity.

In **a holistic approach to problem solving** few essential elements are considered such as: elements determining a project problem, different opinions and ways of thinking of project team members, needs and expectations of various groups of interests, working methods and know-how, organizational

[5] B. Blichfeldt, P. Eskerod, *Project portfolio management – There's more to it than what management enacts*, „*International Journal of Project Management*" 2008, Volume 26(4), p. 357-365; S. Collyer, C. Warren, Project management approaches for dynamic environments, „*International Journal of Project Management"* 2009, Volume 27, p. 355-364; S. Elonen, K. Artto, *Problems in managing internal development projects in multi-projects environments,* „*International Journal of Project Management*" 2007, Volume 21(6), p. 395-402; P. Gardiner, *Project Management: A Strategic Planning Approach, Palgrave MacMillan, Hempshire 2005; J. Sheffield, S. Sankaran, T. Haslett, Systems thinking: taming complexity in project management,* „*On The Horizon*" 2012, Volume 20(2), p.124-36.

[6] R.L. Ackoff, *On passing through 80*, „*Systemic Practice and Action Research*" 1999, Volume 12(4), p. 425-430.

[7] S. Cavaleri, J. Firestone, F. Reed, *op. cit*.

[8] N. Repenning, J. Sterman, *Nobody ever gets credit for fixing problems that never happened: creating and sustaining process improvement*, „*California Management Review*" 2001, Volume 43(4), p. 64-88.

[9] J. Appelo, *Leading Agile Developers, Developing Agile Leaders*, Addison-Wesley, Boston 2011.

conditions, IT-backup – it all can have a significant meaning for a holistic approach process to solving a project's problem. It is also important to consider the perspective of effectiveness, which determines efforts to meet the key project criteria. Moreover, any decision-maker has his/her own individual sense of dealing with problem situations which may cause some limitations. The way of thinking can be visualised by a four-level model which displays visible and invisible factors of system thinking. The first level consists of recognised facts and events. Most of the acquired knowledge is based on this level and is superficial. The next level of system thinking involves subtle aspects of the problem, less visible and perceptible in the process of thinking. At the third level, there are structures of the system, whose purpose is to explain the observed phenomena. On the fourth, the most hidden level, are mental models that are instinctive and habitual reactions to a complex and uncertain project environment. The effectiveness of a holistic approach to problem solving is therefore based on understanding the structure of the problem, the phases and the application of all levels of systems thinking.

The next important issue of systems thinking in project management is to understand the cause-and-effect processes and related phenomena, which build **the network of interactions** in a project. One of the key assumptions says that the cause and effect are often connected in a feedback loop. The understanding of its functioning and the influence on other loops with whom a problem can be connected, becomes an important issue to complex matters such as project management. Feedback loops can be helpful in understanding variables which influence and drive observed events and in understanding patterns of mutual interactions between factors and their possible influence on potential delays. An important aspect is therefore to build a dynamic structure of the project to anticipate and recognize the real situations and relationships in a complex system, called a project and use these experiences in future projects[10]. Some research on the feedback loop show repeating patterns referred to as systemic archetypes, which can be seen as a useful tool in identifying points of leverage and the reasons that should be at the heart of difficult and complex problems[11].

Planning scenarios and modelling action strategies becomes an important sphere of systems thinking, since they can provide a particular role in admitting different points of view of various project stakeholders[12]. The aim of this approach is to develop and test **possible scenarios proceedings in a dynamic and complex system**. Scenarios planning and modelling action strategy may be applied prospectively in the evaluation of the system concept and retrospectively to evaluate the implemented system. Such an approach assumes that individuals have the relevant information, which is a piece of the whole system that needs to be known in order to illustrate the whole problem. Dependencies between cause and effect form the basis for creating a variety of scenarios, selected because of their relevance to the project. Key project stakeholders (e.g. project management,

[10] J.M. Lyneis, K.G. Cooper, S.A. Els, *Strategic management of complex projects: a case study using system dynamics*, „*System Dynamics Review*" 2001, Volume 17(3), p. 237-261.
[11] F. Vester, *Die Kunst vernetzt zu denken. Ideen und Werkzeuge für einen neuen Umgang mit Komplexität*, Deutscher Taschenbuch Verlag GmbH & Co. KG, München 2002, p.32.
[12] M.C. Jackson, *Systems Thinking: Holism for Managers*, Wiley, Chichester 2003, p.22.

steering committee) may engage themselves in scenario planning at certain intervals to actively respond to the changing project environment[13]. Developing action strategies allows creating a model management, which includes a certain set of activities that can be used to affect the problematic situation called a complex project.

Systems thinking in project management determine the need for a **specific behaviour and team approach to the project**. This approach requires a high level of adaptation to change. In this situation, the adaptation is based on learning through action, creativity, focus on innovation and knowledge sharing. There is a heavy volume of social processes that require concentration on relationships and learning through experience. This means openness and agility in managing problems in the project. Project teams operate in a dynamic and complex environment, relying on its activities of the process of continuous learning and development through practice acquired from the project. Therefore an organizational culture based on continuous changes in the organizational aspects minimizing organizational aspects which may cause a resistance to adaptability, becomes important[14].

Having considered key spheres of systems thinking in project management, it becomes important to compare it with traditional and agile approaches to project management (Table 1).

Table 1. Alternative approaches towards project management

	Traditional approach	**Agile approach**	**Systems thinking**
Approaches to problem solving and project goals	• detailed definition of project objectives based on the SMART method • cascade of long and short-term objectives based on a careful analysis of needs	• elaborate a general nature or concept of what has to be the result of a project • objective of the project team is primarily to provide values to the customer based on the principle of "the emergence of effects"	• a comprehensive and holistic approach to problem solving • defining a project problem taking into account different points of view (regarding different stakeholders of the project) • mapping the objectives, regarding different aspects of the project (not just efficiency)
Cycle of project management	• linear project management cycle based on well-defined stages of the project • planning based on a detailed timetable, which is the basis of project management	• iterative (based on delivering functional elements) and incremental project management cycle • adaptability processes and adapting to changing conditions - responding to change is more important than sticking to the plan • close collaboration with the beneficiaries of the project (customers) • processes totally simplified	• non-linear project management cycle based on cause-effect relationships in a complex environment • analysis of the interaction between various elements in the project • developing possible alternative Project scenarios • developing opportunities to manage change (manageable and non-manageable factors) • dynamic change management

[13] P.J. Schoemaker, *Scenario planning: a tool for strategic thinking, „Sloan Management Review"* 1995, Volume 36(2), p. 25-40.
[14] J. Firestone, M. McElroy, *Key Issues in the New Knowledge Management*, Butterworth-Heinemann, Boston, 2003.

Organizational aspect of a project	• work organization precisely defined on the basis of the Work Breakdown Structure • high rate of project formalization • precisely defined organizational structure • focus on maintaining a balance between the key limitations • of the project (cost, quality, time)	• work organization simplified to a maximum, focused on flexibility, speed and adaptability • low rate of formalization	• work organization focused on flexibility and efficient functionality of a system • organization capable of developing and adapting quickly to dynamic environments due to the high competence of the project team
Personal aspect and project team	• work based on narrow field specialists • high competences of the members of the project team, particularly in the area of knowledge and experience • democratic leadership style (integrative) dependable on the specifics of the project and its implementation of institutional forms • task-oriented managing style	• work based on self-disciplined and self-organized teams • high competence of team members (knowledge, personal and behavioural predisposition) • cooperative work and decision making • high level of communication and interaction in a team • customers are included in the project; they create the final value • cooperating leadership team management style, based on steering rather than controlling	• work based on interdisciplinary teams • learning project problems from different perspectives and holistically • assumes that the project problem is more complex than was primarily expected and includes many extra elements and links • problem solving based on moderated meetings focused on cause- and effect relations of a problematic situation • exchange of opinions and visualization of network dependencies in a project • implementation of creative thinking techniques • democratic leadership style oriented on participation of members of the project team • regular meetings and work of project teams

Source: based on: M. Trocki, B. Grucza, K. Ogonek, *Zarządzanie projektami*, PWE, Warszawa 2009; J. Highsmith, *Agile Project Management: Creating Innovative Products*, Pearson Education 2009; M. Brzozowski, T. Kopczynski, *Agile project management approach to managing innovation in SMEs*, Proceedings of the 6th Knowledge Cities World Summit, KCWC-2013. Istanbul, Turkey, 9-12 September 2013, Lookus Scientific, 368-376; C.E. Conforto, D. Capaldo Amaral, *Evaluating an Agile Method for Planning and Controlling Innovative Projects*, "Project Management Journal" 2010, Volume 41(2), p.73–80; R. Gareis, *Management of the project - oriented company*, in: P.W. Morris, J.K. Pinto (eds.), *The Wiley Guide To Managing Projects*, John Wikey & Sons, Inc., Hoboken 2010, p.123-143; J.G. Geraldi, *The balance between order and chaos in multiproject firms: A conceptual model*, "International Journal of Project Management" 2008, Volume 26, p.348–356; M. Martinsuo, P. Lehtonen, *Role of single-project management in achieving portfolio management efficiency*, "*International Journal of Project Management"* 2007, Volume: 25, p.56-65; J. Meredith, S. Mantel, *Project Management: A Managerial Approach*, John Wiley & Sons, Hoboken 2003; J. Pollak, *The changing paradigms of project management*, "International Journal of Project Management" 2007, Volume 25, p.266-74; M. Saynisch, *Mastering Complexity and Changes Projects, Economy, and Society via Project Management Second Order (PM-2)*, *"Project Management Journal"* December 2010, p.4-20.

The comparison of alternative approaches to project management has shown that systems thinking can be a complement to the traditional and agile approaches to project management, not an alternative methodology. Despite many differences in traditional and agile approaches, their similarities are also important with respect to both approaches, particularly the agile approach.

Research method and general results

The research was carried out in 184 companies located in Poland. Sampling was done based on the Kompass directory which lists Polish organizations. Sampling was done according to the data in the NACE classification. Organizations having more than 50 employees were included in the sample. All project managers participated voluntarily in an on-line survey.

Table 2. Expectations and actual application of systems thinking in project management

	Opinions / expectations of the management of projects	**Actual condition occurring in project management**
A holistic approach to problem solving	High expectations of managers concerning the various elements of the project problem, as well as methods and tools of work Average evaluation = 4.0	A low level of taking into account the needs and expectations of various stakeholders of the project and opinions of the ultidisciplinary project team members Average evaluation = 2.91
The network of interactions	Relatively high level of taking into account cause – effect relationships between the internal factors of the project and its relations with the environment of the project Average evaluation = 3.82	A medium level of taking into account the cyclic phenomena in the project and of cause – effect relationships with the environment of the project Average evaluation = 2.83
Role plays scenarios in dynamic and complex systems	A relatively high level of taking into account the strategy of action containing the manager's set of actions, allowing for interference in the problematic situation which is a project Average evaluation = 3.71	A medium level of taking into account the strategy of action containing a set of the manager's actions, allowing for interference in the problematic situation which is a project Average evaluation = 3.12
A project team approach	A high level of taking into account creativity and team work based on trust and unfettered communication Average evaluation = 4.31	A medium level of taking into account the level of team adaptability to change, continuous learning and development of the team and the work based on trust and communication Average evaluation = 2.98

Respondents in the survey rated each characteristic using a 5-point Likert-type scale, ranging from rate 1 (is not present) to rate 5 (is present).
Source: own research.

To determine the actual and expected rate of systems thinking in project management, all the elements characteristic for systems thinking and project management in four main areas were collected and grouped (table 2):

1. A holistic approach to problem solving – includes the identification of a project problem (creating a map of the problem situation), and a network for monitoring and controlling the project problem;

2. The network of interactions – includes elements related to identifying the cause and effects- dependencies;
3. Role plays scenarios in dynamic and complex systems – involves developing action strategies (of an executive model) containing a set of activities that allow for intervention in a problematic situation which is the project;
4. A project team approach- covers elements related to the functioning of the project team, and in particular the level of adaptation of the team, team creativity, continuous learning and development of the team, working based on trust and communication.

It should be emphasized that any attempt to answer the research questions is a difficult task, in particular because of the complexity of project management, especially the low level of awareness and knowledge of systems thinking. Another aspect that was taken into consideration is declarative data obtained, which was taken as a limitation and resulted in the need for careful and critical evaluation of the results and conclusions. Despite these shortcomings, an attempt was made to use different analytical methods including the independent two-sample t-test and one-way ANOVA assessment.

The obtained results, statistical analysis and logical reasoning helped to form the following deductions:

1. There is a gap between expectations and management practice in terms of using systems thinking in projects management, but the gap isn't large.
2. The indicated gap mainly concerns the need for considering the complexity of the project problem and the need for a broad approach to project management, which takes into account the interests of different groups.
3. The inclusion of the project team and its specific competences as a key resource of network and systems thinking in project management is particularly important.
4. Identified cause-effect relationships exist mainly between the internal factors of the project, and they occur less frequently in relations with external project environment's representatives.
5. There is a perceptible need for an extended implementation of scenarios in dynamic and complex projects.
6. There is a significant gap between expectation of the respondents and reality in relation to the area of the project team approach, which takes into account: the level of adaptation, creativity, development, level of trust, and team communication.

Summary

The given results led to the implementation of the objectives connected with evaluation of the present approach to project management in enterprises, their effectiveness and the factors determining their effectiveness, as well as the actual and desired state of using systems thinking in project management. In the light of these considerations, it is proved that:

- Project management is based mainly on methodological aspects of management.
- There is a wide spectrum of areas that determine the efficiency of project management and awareness of its importance among the management does

not translate into actual use in practice. It was also proved that there is a low project maturity in enterprises and the social aspect is marginalised.
- There is a gap in the field of systems thinking in project management, which can be seen in the divergence of expectations of executive management with management practices in this regard.

The most important theoretical implication arising from the research is a conclusion that systems thinking should be seen not as an alternative to traditional project management but rather as a certain way of thinking and an approach to the problem, which combines and integrates different approaches, theories and concepts, including contemporary ambient conditions characterized by dynamism and complexity. The most important practical implication is a conclusion that enterices should implement elements of systems thinking in project management to achieve a higher level of project management maturity and to accomplish a more holistic, strategic approach towards project management in multi-project environments.

Recommendations for future investigation include examining presented theoretical framework by undertaking empirical research in other countries. A complementary area of research should be to investigate the relationship between systems thinking and project portfolio management.

Bibliography

Ackoff R.L., *On passing through 80,* "*Systemic Practice and Action Research"* 1999, Volume 12(4), p. 425-430.

Appelo J., *Leading Agile Developers, Developing Agile Leaders*, Addison-Wesley, Boston 2011.

Blichfeldt B., Eskerod P., *Project portfolio management – There's more to it than what management enacts*, "*International Journal of Project Management"* 2008, Volume 26(4), p. 357-365.

Brzozowski M., Kopczynski T., *Agile project management approach to managing innovation in SMEs*, In: *Proceedings of the 6th Knowledge Cities World Summit*, KCWC-2013. Istanbul, Turkey, 9-12 September 2013, Lookus Scientific, p. 368-376.

Cavaleri S., Firestone J., Reed F., *Managing project problem-solving patterns*, "*International Journal of Managing Projects"* 2012, Volume 5(1), p. 127-140.

Checkland P., *Soft systems methodology: a 30-year retrospective*, In: Checkland P., Scholes J. (eds.), *Soft systems methodology in action*, Wiley, Chichester 1999, p. A1–A65.

Collyer S., Warren C., *Project management approaches for dynamic environments,* "*International Journal of Project Management*" 2009, Volume 27, p. 355-364.

Conforto C.E., Capaldo Amaral D., *Evaluating an Agile Method for Planning and Controlling Innovative Projects*, "*Project Management Journal*" 2010, Volume 41(2), p. 73–80.

Elonen S., Artto K., *Problems in managing internal development projects in multi-projects environments*, *"International Journal of Project Management*" 2007, Volume 21(6), p. 395-402.

Firestone J., McElroy M., *Key Issues in the New Knowledge Management*, Butterworth-Heinemann, Boston 2003.

Gardiner P., *Project Management: A Strategic Planning Approach*, Palgrave MacMillan, Hempshire 2005.

Gareis R., *Management of the project-oriented company*, in: Morris P.W., Pinto J,K. (eds.), *The Wiley Guide To Managing Projects*, John Wikey & Sons, Inc., Hoboken 2010, p. 123-143.

Geraldi J.G., *The balance between order and chaos in multiproject firms: A conceptual model*, *"International Journal of Project Management"* 2008, Volume 26, p. 348–356.

Highsmith J., *Agile Project Management: Creating Innovative Products*, Pearson Education 2004.

Jackson M.C., *Systems Thinking: Holism for Managers*, Wiley, Chichester 2003.

Lyneis J.M., Cooper K.G., Els S.A., *Strategic management of complex projects: a case study using system dynamics, "System Dynamics Review"* 2001, Volume 17(3), p. 237-261.

Martinsuo M., Lehtonen P., *Role of single-project management in achieving portfolio management efficiency*, "International Journal of Project Management" 2007, Volume 25, p.56-65.

Meredith J., Mantel S., *Project Management: A Managerial Approach*, John Wiley & Sons, Hoboken 2003.

Pollak J., *The changing paradigms of project management, "International Journal of Project Management"* 2007, Volume: 25, p. 266-74.

Remington K., Pollack J., *Tools for complex projects*, UK Gowerment, Aldershot, Hampshire 2007.

Repenning N., Sterman J*., Nobody ever gets credit for fixing problems that never happened: creating and sustaining process improvement*, *"California Management Review"* 2001, Volume 43(4), p. 64-88.

Saynisch M., *Mastering Complexity and Changes Projects, Economy, and Society via Project Management Second Order (PM-2)*, *"Project Management Journal"* December 2010, p.4-20.

Schoemaker P.J., *Scenario planning: a tool for strategic thinking*, "Sloan Management Review" 1995, Volume 36(2), p. 25-40.

Sheffield J., Sankaran S., Haslett T, *Systems thinking: taming complexity in project management*, "On The Horizon" 2010, Volume 20(2), p.124-36.

Sterman J., *System dynamics modeling for project management*, *"Projects and Profits"* 2002, Volume II, p. 43-54.

Trocki M., Grucza B., Ogonek K*., Zarządzanie projektami*, PWE, Warszawa 2009.

Vester F., *Die Kunst vernetzt zu denken. Ideen und Werkzeuge für einen neuen Umgang mit Komplexität*, Deutscher Taschenbuch Verlag GmbH & Co. KG, München 2002.

Williams T. M*., Modelling Complex Projects*, Wiley, Chichester 2012.

Yeo K.T., *Systems thinking and project management – time to reunite*, "International Journal of Project Management" 1993, Volume 11(2), p. 111-117.

Yeo K.T., Lim C. K., *Sources of information systems failure: a systemic perspective*, *"Journal of Applied Systems Studies"* 2000, Volume 1(2), p. 312-326.