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Revija Management je namenjena mednarodni znanstveni javnosti; izhaja v angleščini s povzetki v slovenščini. Izid revije je finančno podprla Javna agencija za raziskovalno dejavnost Republike Slovenije iz sredstev državnega proračuna iz naslova razpisa za sofinanciranje izdajanja domačih znanstvenih periodičnih publikacij.

management

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Guest Editor's Introduction to the Thematic Issue

What should the risk level of loosing sustainable operative competitive advantage be in turbulent business environment? What might be the sustainable competitive operations (OP) and technology/knowledge strategies when the world economy is in turbulence for different reasons?

The studies on global manufacturing strategies created separate results to be integrated into resource allocations to implement strategies when we can't be at all sure about the long term business environment. Competitive categories (prospector ... reactor) might be integrated into sense and respond (S&R) resource and technology allocations by the S&R attributes according to their influence to cost, time, quality or flexibility performance. The importance of different technology levels (basic, core or spearhead) affects strategy implementation. The knowledge required to create the chance to build dynamically the future change of competitive operations strategy varies a lot according to the technology/knowledge ranking versus their effect to performance, and versus acceptable operative sustainable competitive advantage level and especially versus the risk level (probability by which the operations strategy has to be essentially changed in the near future).

By case studies from traditional industries and knowledge intensive services, it has been possible to find out a preliminary model between the technology and OP strategies preferred. We should be able to answer what risk level we should take and bear to be strong (resilient) enough all the time against the different turbulences?

We are grateful to the organizers of the Make Learn 2015 conference (http://makelearn.issbs.si/) who preselected ten papers for the review process. After about 20 reviews, five papers have been accepted to be published in this thematic issue. We express our special thanks to the writers of these approved papers.

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Business Ecosystem Definition in Built Environment Using a Stakeholder Assessment Process

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Actors and their relationships are core elements of the business ecosystem concept, a trending model of business collaboration emphasizing organizational diversity, relationship dependency and joint evolution. This study approaches a built environment business ecosystem to structure the acknowledged complexity of ecosystem definition by applying a three-step stakeholder assessment process. The process is based on a stakeholder network diagram, Mitchell, Agle, and Wood's (1997) well-recognized stakeholder salience model and a two-dimensional stakeholder matrix. The assessment process is applied to a school campus case study to define a built environment business ecosystem and the salience of the ecosystem actors. Results, including salience score calculation, validate the applicability of the proposed process. The findings provide novel insights for ecosystem researchers into how stakeholder theory concepts can be applied to broaden the understanding of business ecosystem dynamics.

Key words: business ecosystem, business in built environment, salience model, stakeholder assessment

Introduction

'Business Ecosystem' is becoming an established term in business and management science (Moore 1993; 1998). The adaptive nature, unclear boundaries and complexity of interactions are apparent as a lack of a single, clear definition of 'Business Ecosystem' amongst scholars (Iansiti and Levien 2004; Gobble 2014). As self-organized, evolving entities, the ecosystems have analogies with meta-organizations and social networks, inheriting from organizational theories (Gulati, Puranam, and Tushman 2012). Many recent studies (e.g. Ceccagnoli et al. 2012; Dass and Kumar 2014; Gawer and Cusumano 2014; Gobble 2014) conclude that ecosystems are formed around a certain project, innovation or service that is being operated by the ecosystem's *central actor*.

Business ecosystem actors in general are all organizations involved – either directly or indirectly – in the ecosystem value cocreation process orchestrated by the central actor. Actors share a common system-level goal and are mutually dependent in performing value against the goal (Iansiti and Levien 2004; Gossain and Kandiah 1998). As they are unique, multi-organizational and dynamic business entities, defining ecosystems is a complex, case-specific activity (Aaltonen and Kujala 2010; Iansiti and Levien 2004). A lack of an unambiguous business ecosystem definition process decreases opportunities to compare ecosystem research results.

A project stakeholder is defined by Bryson (2004) as an individual or a group who has an interest or some aspect of right or ownership in the project, can contribute to the project or be impacted by the project. Therefore, 'business ecosystem actor' as a term has similarities to a stakeholder in project business literature, with higher emphasis on ecosystem definition through actors. Stakeholder theory attracts attention in academic research, since maintaining an appropriate balance among stakeholder interests and gaining their support includes potential benefits for the focal firm (Mok, Shen, and Yang 2015).

A business ecosystem's actors feed the achieved benefits back to the business ecosystem through the stakeholder network (Post, Preston, and Sachs 2002). This study contributes to the academic discussion on business ecosystems by identifying the ecosystem actors and their dependencies, using a three-step stakeholder assessment process initiated from stakeholder management literature.

The Public-Private-Partnership (PPP) model introduces long-term co-operation and co-evolution into built environment projects, enabling them to be discussed as business ecosystems (Leviäkangas, Kinnunen, and Aapaoja in press; Pongsiri 2002). Increased interaction between customer and other built environment stakeholders leads to higher expectations of the value delivered throughout the project life. Aapaoja, Kinnunen, and Haapasalo (2013) suggest that under these conditions, the ecosystem's focal actors should put more emphasis on stakeholder management, making the built environment more customer- and stakeholder-driven. The stakeholder assessment in this study is done during the operations phase of a built environment project, complementing the construction project research field findings focusing mostly on the project planning and building phases (Mok, Shen, and Yang 2015).

As presented in this study, one possibility in approaching the complexity related to the ecosystem definition task is to model the ecosystem actors and their relationships as a stakeholder network. The study aims to broaden the understanding of built environment dynamics in the operations phase and to shed light on the underlying business ecosystems with the following research questions:

Q1 *How is the business ecosystem mapped as a stakeholder network?*

Q2 *How is the business ecosystem actors' salience defined?*

Research question 1 is outlined through a literature review and case study, where a school campus PPP ecosystem is described as a stakeholder network. Research question 2 is answered by evaluating the case study ecosystem actors' salience, using Mitchell, Agle, and Wood's (1997) salience model. The process of the ecosystem description introduces an applicable framework within which to research built environment business ecosystems. The framework decreases complexity related to the business ecosystem concept definition discussed amongst scholars (Dass and Kumar 2014; Gawer and Cusumano 2014), and it contributes to project business literature by elaborating stakeholder roles in the built environment project operations phase. Through these contributions, we aim ultimately to provide practitioners a methodology by which to initiate and orchestrate business ecosystem activities.

Business Ecosystem Roles and Value Co-Creation

The central actor's role is the starting point in modelling a business ecosystem. In a business ecosystem, the long-term wealth is determined by relationships rather than transactions (Gossain and Kandiah 1998). Relationships imply continuity, conflict and collaboration (Post, Preston, and Sachs 2002). All actor roles in an ecosystem belong to the list of stakeholders. They are impacting or are being impacted by the ecosystem value co-creation and the achievement of system-level goals (Moore 1996; Letaifa 2014). In a business ecosystem, the system-level value co-creation process is set to create more value for the ecosystem's end users, together, than the individual players could generate as independent actors (Gawer and Cusumano 2014). Value capture defines how the customer accepts the value created for it (Letaifa 2014). Inside the ecosystem, the participants may have different perceptions of the customer and the goals (Gossain and Kandiah 1998; Winch and Bonke 2002). Clarification of the system-level value co-creation and capture is done in this study through defining the ecosystem actors and their relationships.

Every relationship of a business ecosystem contributes to the value co-creation either positively or negatively (Ramaswamy and Gouillart 2010). In a case where the ecosystem actors' incentives are not aligned, the ecosystem will not become successful in the long term (Letaifa 2014). The ecosystem dependencies increase the risk for actors, as the success is not controlled by their own effort (Adner 2006). This is likely to happen in a case where an actor has critical capabilities for the value co-creation, but the targets do not support the system-level goals. Actors and goals are interdependent in a business ecosystem (Adner and Kapoor 2010).

Stakeholder Assessment

Stakeholders of an ecosystem include organizations not directly involved in the value co-creation (Davis 2014; Donaldson and Preston 1995). Stakeholders can be divided into internal or external (e.g. Clarkson 1995) or viewed in a wide sense or a narrow sense (Freeman 1984), depending on whether they are acting within the identified system or hold critical capabilities with respect to the system functions. Internal stakeholders are considered critical for the central actor to survive (Clarkson 1995). The stakeholder interaction may also happen at a higher level between business networks and ecosystems (Majava et al. 2014). These definitions set interactions, goals and the resource exchange process as central elements in stakeholder management, making stakeholder theory applicable to business ecosystems research.

Clear roles and responsibilities ensure that every stakeholder has access to relevant information and that the actor most capable of performing a specified task is identified, adding up to the prosperity of the business ecosystem. For an actor, the alignment between expectations and performance illuminates the opportunities to benefit from the surrounding relationships (Adner 2006). It helps in directing attention, for example, in changes. Modelling the stakeholder network and assessing the stakeholder impact contribute to the sustainability of the ecosystem, increase flexibility and provide a baseline for the ecosystem's successful renewal (Gobble 2014; Iansiti and Levien 2004).

Stakeholder network modelling builds on the Industrial Purchasing and Marketing (IMP) group's approach in that the relationships should be analysed as networks, not as dyadic nodes, as the relationships are interconnected (Ford 1990). The Activities, Resources, Actors (ARA) model defined by Håkansson and Johansson (1992) describes how a network can be analysed through individual substance levels. Bryson (2004) similarly utilizes different relationship types to characterize how the stakeholders contribute to the value co-creation process.

The network and relationship analysis starts by identifying the organizations with which the central actor interacts and modelling them as a stakeholder network diagram (Fassin 2008; Freeman 1984). The identified stakeholders are categorized using resource dependency relationships to formulate their roles in value co-creation and to identify relevant stakeholders for further assessment (Donaldson and Preston 1995; Aapaoja and Haapasalo 2014). Aapaoja, Kinnunen, and Haapasalo (2013) and Aapaoja and Haapasalo (2014) refine the Clarkson (1995) stakeholder grouping in more detail, categorizing the stakeholders as primary, secondary, key supporting participants, tertiary and extended. Primary, secondary and key supporting stakeholders belong to internal stakeholders, while tertiary and extended belong to external stakeholders (Clarkson 1995).

Defining the relationships between the stakeholders extends the stakeholder network from a central actor-specific view to the business ecosystem view (Moore 1998). The business model description of the stakeholders characterizes the ecosystem's value co-creation process through the interaction web and clarifies whether the actors' incentives are aligned with the system-level goal (Aaltonen and Kujala 2010).

Stakeholder impact information in the network enables prioritization. The stakeholder salience model introduced by Mitchell, Agle, and Wood (1997) is a widely used description of how the stakeholders and their relationships contribute to a project, or similarly, to a business ecosystem. The correlation between the salience and allocated management priority was validated via the case study analysis of Agle, Mitchell, and Sonnenfeld (1999).

The salience model is based on three attributes – *power, legitimacy* and *urgency* (Mitchell, Agle, and Wood; Poplawska et al. in press). *Power* is the attribute of purposefully impacting decision-making (Mitchell, Agle, and Wood 1997). *Legitimacy* can be defined as an attribute that impacts the decision making with respect to socially acceptable claims such as a contract, a legal right or a moral concern

(Agle, Mitchell, and Sonnenfeld 1999). *Urgency* is the stakeholder attribute of having an immediate impact due either to the time sensitivity or to the criticality of the issue. Power and legitimacy are considered as the core attributes and urgency as a dynamic or catalytic attribute. A stakeholder's total salience is the sum of the attributes it possesses. It is context-specific and is a relative measure valid only in the ecosystem or project under investigation (Fassin 2008; Mitchell, Agle, and Wood 1997).

Stakeholders can form alliances or coalitions to combine salient attributes for stronger impact, especially if the coalition is formed with a more powerful or legitimate partner (Fassin 2008; Savage et al. 1991; Aaltonen, Kujala, and Havela 2013). Coalitions can be used to push through challenging decisions in the network and are identifiable via stakeholders' relationships in between (Newcombe 2003).

Johnson and Scholes (1999) visualized the stakeholder's power with impact probability (impact interest) in a two-dimensional power-interest matrix (Johnson and Scholes 1999). The two-dimensional stakeholder assessment model has been applied by several scholars with stakeholder strategies (Olander and Landin 2005; Aapaoja and Haapasalo 2014). The matrix format presents the stakeholder groups as dynamic entities, allocates suitable stakeholder management strategy and extends the applicability of group typology to different cases (Aapaoja and Haapasalo 2014).

Built Environment Business Ecosystem

A built environment project is a complex system producing highly customized, engineering-intensive products that require several producers to work together (Hobday 1998). Size and complexity create challenges to the project management, as follows: (1) a large number of stakeholders lead to a complex stakeholder network, (2) dynamics and several interfaces increase uncertainty and (3) a high public profile increases pressure and the possibilities for controversy (Mok, Shen, and Yang 2015). The stakeholder's role for project success through the life cycle is being emphasized in the academic literature in the 21st century, especially with complex projects and their networks (Davis 2014).

Built environment projects driven by the public sector are considered fragmented systems where participants' goals are not necessarily aligned and central governance is inefficient. External stakeholders like local residents, financing agencies, regulators and community groups create pressure. Many stakeholder research designs in built environments address planning and building phases, yet the operations phase is not deeply covered. Traditionally, the ownership of the facility is transferred from a private constructor to a public owner once the building phase is completed. This transfer increases complexity in projects and leads to changes in the stakeholder network (Mok, Shen, and Yang 2015).

PPP is a collaboration model where the public sector – like the state or government – initiates a facility project, but private sector actors finance, build and operate it on behalf of the public sector actor against leases, rents or other financial compensations (Leviäkangas, Kinnunen, and Aapaoja in press). PPP covers planning, building and operations of the facility to overcome the costs and risks involved in ownership transfer in a traditional project. The partnership between the stakeholders is based on long-term contracts that empower the private investors to construct the facility and to provide services to the public users (De Schepper, Dooms, and Haezendonck 2014).

The uniqueness of the projects and the irreversibility of the decision-making are project business-specific characteristics leading to a lack of routines and established processes. This complicates the project scope definition similarly to the ways identified with business ecosystems (Cleland 1986; Aaltonen and Kujala 2010; Artto and Kujala 2008; Gobble 2014). Projects take the basic operation principles, goals and resources from the ecosystem actors and feedback the deliverables, experiences and benefits (Yang et al. 2011). This is supported in De Schepper, Dooms, and Haezendonck's (2014) proposal that in a PPP initiative, a detailed stakeholder assessment, including the relationships between stakeholders, contributes positively to the project's success.

At any given lifecycle phase, certain stakeholders are more salient due to their capability of satisfying phase-specific critical needs (Jawahar and McLaughlin 2001). The official role of a stakeholder may differ from the stakeholder's practical impact. A difference between an official role and performed practice can be caused by expectations not being clear or by a low level of involvement in the built environment-planning phase (Gobble 2014; Aapaoja, Kinnunen, and Haapasalo 2013). The central actor is to ensure that the stakeholder's performance and expectations are balanced (Adner and Kapoor 2010).

A built environment project implements the underlying business ecosystem. Modelling of the ecosystem is challenging, but as the ecosystem actors are analogous to stakeholders in project business, the hypothesis of this study states that the stakeholder assessment process can be used to define a built environment business ecosystem. The assessment process steps defined, based on the literature review, are the following.

1. Map the stakeholder network using a network diagram.
2. Define stakeholder impact using Mitchell, Agle, and Wood's (1997) salience model.
3. Group and prioritize the stakeholders using the stakeholder assessment matrix.

Methodology

This study applied the stakeholder assessment process in a school campus case study in Oulu, Finland. The campus building was finalized and the project ended in 2013, and the building is now in the operations phase in the PPP model. A single case study is a suitable method by which to conceptualize topics not widely studied, and this method has been applied in a number of research contributions to project business, stakeholder and business ecosystem theories (e.g. Savage et al. 1991; Mitchell, Agle, and Wood 1997; Adner and Kapoor 2010; Yang et al. 2011). It illustrates characteristics of a unique environment such as a business ecosystem. It can expand the emergent theory, but it has limited generalization opportunities due to its small sample size (Eisenhardt 1989).

The study was initiated with a literature review on business ecosystems and stakeholders in project business. Secondary data like newspaper articles and public documents about the campus were assembled to gather general knowledge. The construction company who is now responsible for the campus PPP operations was selected as the case study central actor.

Semi-structured interviews of campus stakeholders as ecosystem actors were used as a data collection method (Thomson et al. 2012; Metcalfe and Sastrowardoyo 2013). The interview process started with the central actor. The snowball sampling technique (Goodman 1961) was used to identify the campus stakeholders and to model the interactions between them. In snowball sampling, the interviewee names the next stakeholders to be interviewed. The sampling process was repeated until no new names came out, that is, until the process was saturated. In total, eight interviews were conducted, following the campus steering group organization available in the public documents. The interviewed sample of stakeholders represents 45% of the identified ecosystem of 18 stakeholders. Interviewed persons who represent organizations using and maintaining the school campus are listed in table 1, with the ecosystem central actor in bold.

TABLE 1 Interviewed Stakeholders

Organization	Actor
Constructor/Operating company	Head of maintenance team (remote)
Facility management company	Facility manager
Facility maintenance company	Maintenance responsible
High school management	Principal
Primary school management	Principal
High school operations	Attendant
Cleaning and catering company	School campus team leader
Oulu City estate management	Head of facilities and PPP initiatives

Questions in the interviews focused on the respondents' views about their main stakeholders, their perception of their importance and their contribution to the campus. The list of questions was modified during the interview process to seize new data opportunities (Eisenhardt 1989). Interview sessions were recorded. The voice recorder files were transcribed into a textual format, and the answers were grouped according to the questions. The final list of questions is below:

1. Describe your and your team/organization role in the school campus.
2. How would you characterize the current phase and how the campus has reached it?
3. What are the most important goals for the campus, and who defines them?
4. Who are your key stakeholders in the campus?
5. What are your expectations for the stakeholders?
6. How is stakeholder interaction and co-operation reflected in the campus goals?
7. What are the stakeholder interactions between the stakeholders?
8. How are the ecosystem goals reflected in the stakeholders' incentives?
9. Is there a defined process in your organization for stakeholder management? (If yes, can you elaborate more?)

Scoping the study during the operations phase builds on Jepsen and Eskerod's (2009) practical challenges in applying a stakeholder assessment for the whole project due to stakeholder network evolution. The assessment process used applies network and matrix analyses from Winch and Bonke (2002). Relationships between the stakeholders were drawn as a network diagram, using resource dependency where connections represent information or resource transaction (Bryson 2004). The diagram was drawn for the first time after the first central actor interview and was updated after subsequent interviews.

The central actor prioritized the stakeholders using the Analytical Hierarchy Process (AHP), a pair wise comparison method introduced in project management by Al-Subhi Al-Harbi (2001). The central actor evaluated the *power, legitimacy* and *urgency* of each stakeholder as compared to every other, using a 1–9 scale when the evaluated stakeholder had a stronger position compared to the target stakeholder, and a 1/9–1 scale when the position was weaker. The result was an eight-parameter matrix. The total score of each salience attribute per stakeholder was calculated by multiplying the scores and taking the second square root of the result. Olander (2007) proposed that power is the most important attribute for decision making, as it is a necessity to raise impact level, and it should be given a relatively higher weighted value when total salience is calculated. Following this proposal, in this study, the weighting factors on salience attributes were 0.4 (power), 0.3 (legitimacy) and 0.3 (urgency).

After concluding the pair wise comparisons, the priority vectors (eigenvectors) can be calculated. Each element in the eight-parameter matrix is divided by the column total, and the priority vector is defined by taking the row averages. The consistency of comparisons is determined by using the eigenvalue (λmax) to calculate the consistency index (CI) and to calculate the consistency ratio (CR) by dividing the CI by the random index (RI). For an eight-parameter matrix, the RI is set as 1.41. In a case when the CR is below 0.10, the prioritization judgement matrix is consistent (Al-Subhi Al-Harbi 2001; Aapaoja, Kinnunen, and Haapasalo 2013).

Once the salience score was defined, the stakeholders' impact probability was estimated by the central actor, using a 1–5 scale in free-form discussion. As a final step, the stakeholders were mapped into a two-dimensional stakeholder assessment matrix to visualize the assessment conclusion on the impact of probability and salience.

Results

As the first step of the assessment process, the key stakeholders for the school campus central actor are presented in a network diagram (Fassin 2008) in figure 1, also scoping the campus ecosystem.

Campus steering group members that were interviewed are in bolded black circles. Dependencies and their densities present the

FIGURE 1 School Campus Stakeholder Network (dark – campus steering group members)

fact that the high school management, primary school management, facility managing company and facility maintenance company are the key internal stakeholders for the central actor (constructor) from the steering group. The central actor is located in another city (Helsinki), and local daily operations of the school campus are carried out by the key stakeholders. These stakeholders have critical resources for the central actor and have access to set requirements in the agreed-upon requirement management system. High school management and primary school management represent the end user or the ecosystem customer. They consolidate requirements from other users and manage the daily usage of the campus, thus driving the value co-creation.

TABLE 2 School Campus Ecosystem Stakeholders' Salience: Central Actor View

Stakeholders	Power	Legitimacy	Urgency	Salience
Constructor/operating company	0.016	0.085	0.017	0.037
High school management	0.698	0.448	0.410	0.537
High school operations	0.090	0.036	0.130	0.086
Primary school management	0.162	0.197	0.410	0.247
Facility maintenance company	0.004	0.048	0.003	0.017
Facility management company	0.012	0.048	0.012	0.023
Oulu City estate management	0.015	0.104	0.015	0.042
Cleaning and catering company	0.002	0.034	0.003	0.012
Consistency ratio	5.805	3.607	3.025	

Oulu City estate management is a private company publicly owned by the City of Oulu. The company is responsible for all built environment properties in Oulu, including the financial liabilities of PPPs. Facility management has several interfaces and participates in the campus steering group, but as they are not operating the campus on a daily basis, their role remains more distant. The cleaning and catering service provider is another distant stakeholder for the central actor, but with a different profile. They participate in the daily campus activities, but their contribution is valued most directly by the end users such as teachers and students.

As a next step, the central actor evaluated the stakeholders' salience through a pair wise comparison and an AHP calculation process. The results of the salience scoring are presented in table 2.

The high school management's role as the most salient stakeholder for the central actor is confirmed in table 2. As the ecosystem customer with the most frequent interaction with the central actor, their value perception drives the ecosystem value co-creation. The high school management is a long-term member of the ecosystem. They have already been involved in the planning phase by defining requirements for the spaces etc. Long participation binds a stakeholder tightly into the ecosystem, as proposed by Aapaoja, Kinnunen, and Haapasalo (2013).

The primary school management's role is officially similar, but its lower salience score suggests a weaker true impact. Table 2 defines the Oulu city estate management as a legitimate stakeholder yet not powerful or time critical. This is aligned with the results of the interview-based network diagram in figure 1. Higher than 0.10 CR values for all salience attributes indicate a polarized impact of the stakeholders. Stakeholders with a customer role have high impact on the central actor, whereas actors in a subcontracting relationship with the central actor have low impact.

Both figure 1 and table 2 indicate that the role of the facility management company is not well established in the ecosystem in terms of expectations and performance. Facility management should be accountable for the campus operations, but the daily operations are organized directly between the school's management and the central actor. Bypassing of the role set for the local facility management creates a contradiction that is visible as overlapping connections in figure 3, reflecting the expectation-performance challenge presented by Gobble (2014).

The expectation-performance gap may be temporary and due to a recent personnel change in the facility management company, but regardless of the root cause, the findings characterize how the utilization of a formal stakeholder assessment process reveals the ecosystem dynamics and frames the challenges related to stakeholders' relationships, expectations and true performance (Adner 2006).

The third step in the stakeholder assessment is concluded in figure 2, where the salience score from table 2 and the impact probabilities evaluated by the central actor are presented as a two-dimensional matrix. The assessment matrix utilizes the template defined by Aapaoja and Haapasalo (2014). The matrix provides a simplified view of the school campus business ecosystem in its operational base, enabling further stakeholder management actions.

The stakeholder assessment matrix presents the view that the campus is in a steady operational phase where the activities are concentrated on campus users and maintenance organizations (B, D, C, A). Internal stakeholders for the central actor comprise the closest and longest-term participants from the campus steering group, presented through salience evaluation.

Discussion

The findings of the study validate the fact that a business ecosystem collaboration concept can be defined by applying a three-step stakeholder assessment process including a stakeholder network diagram, Mitchell, Agle, and Wood's (1997) stakeholder salience model with pair wise comparison and an impact probability-salience matrix. In essence, the process provides a framework that is easy for scholars to apply and for practitioners to use in approaching complex business ecosystem and project environments. Limitations of the results concern the dynamic nature of the business ecosys-

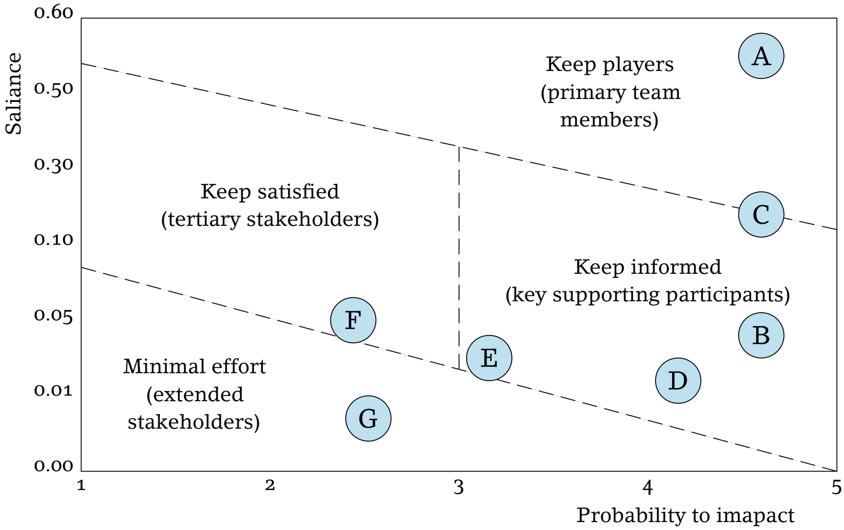

FIGURE 2 Probability and Salience Assessment Matrix (adapted from Aapaoja and Haapasalo 2014; A – high school management, B – high school operations, C – primary school management, D – facility maintenance company, E – facility management company, F – City of Oulu estate management, G – cleaning and catering company)

tem and possible conflicts between the stakeholders' own targets and ecosystem goals. These gaps should be assessed as the next steps through the ecosystem life cycle and value co-creation process assessments. The set-up should be repeated in similar built environment project cases to enable generalizations of the stakeholder salience conclusions and to identify improvements to the ecosystem definition process.

The school campus ecosystem is in an active value co-creation phase where the key actors are investing a lot of effort and resources. Simultaneously, the users are consuming the created value and setting requirements for the campus maintenance organizations. The stakeholder assessment matrix in figure 2 presents the fact that value co-creation of the campus is jointly orchestrated by the central actor and the customer. This merges the value co-creation and value capture processes, defined as separate entities by Ramaswamy and Gouillart (2010). This finding provides an interesting area for further research on business ecosystem value processes.

Aapaoja, Kinnunen, and Haapasalo (2013) brought up the challenge of using a static stakeholder role definition in built environment PPP projects, since due to the longevity of a PPP project, the stakeholders have different roles. The results of this study build on these findings by specifying that the described ecosystem is specific to the operational phase of the project and that the dynamic nature of the ecosystem is reflected through changes in stakeholder roles. In other words, the study emphasizes how project stakeholder management needs to adopt a dynamic approach; a project moves through distinctive phases over its life cycle, requiring different approaches for managing different stakeholders at different points in time (Aaltonen and Kujala, 2010). Aapaoja, Kinnunen, and Haapasalo (2013) also presented the idea that customer roles have the highest salience, which is aligned with the school management's high salience scores in this study.

This study contributes to business ecosystem literature by illustrating the applicability of the stakeholder assessment method to ecosystem definition, as intended in research question 1. It presents a process to suppress the discussion controversies on business ecosystems. Insights on how the campus activities in the operations phase concentrate around a few stakeholders and how it is important to manage the expectations and performance of new stakeholders build forward the knowledge base of built environment projects and their operations. This response to research question 2 describes how the salience analysis brings forward information supporting stakeholder management.

The stakeholder assessment process enables scoping of the business ecosystem as a holistic collaboration entity. The use of the presented methods identifies the ecosystem's key contributors but also helps to define actions to strengthen the ecosystem's own role and to streamline it by excluding the non-value-adding participants. This builds on Gossain and Kandiah's (1998) view that the long-term success of a business ecosystem requires the actors to be truly committed and contribute to the ecosystem's system-level targets and that their business models must be aligned with the ecosystem benefits.

As another further study proposal, an analysis of the transitions of the campus ecosystem in its life cycle through stakeholder changes would illustrate the background of the salience assessment results. In addition, evaluating the stakeholder salience against different ecosystem goals would broaden the understanding of how different stakeholders interpret the ecosystem and how well the system-level goals are actually shared amongst the ecosystem actors.

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Legal and Managerial Implications of the Italian 'Contratto Di Rete'

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Today, innovation and internationalization processes need more programming and high investments in new knowledge and relationships. Through trans-sectorial and trans-territorial networks, SMEs can participate to global dynamics, especially in terms of knowledge sharing and absorbing. We propose that the 'Contratto di Rete' (Network Contract) is an innovative type of formal contract and a central solution in these dynamics. Since its introduction in 2009 by means of the Law Decree 5/2009, the brand-new networking tool has achieved broad success among Italian entrepreneurs. The authors provide an overview of the discipline regulating the tool; a background concerning network and contract theory; and finally a presentation of some best practices through insightful case studies. This approach integrates legal and managerial perspectives, delivering useful implications for scholars and practitioners.

Key words: contracts, Contratto di Rete, networking, SMEs, interfirm aggregations, competitiveness, innovation

Introduction

Most Italian SMEs show unsatisfying results compared to the competitive performance achieved from other European competitors. What is more, they are seriously suffering the competition from emerging market economies' enterprises.

For many Italian SMEs it is difficult to follow modern innovation and internationalization paths. Innovation is the ability of creating products/services that not only are technologically advanced, but also provide original experiences from a psychological and socio-cultural perspective. To support effective innovative processes, companies need to 'open up' as much as possible to external flows of knowledge, and strategically relate with a plethora of actors. Among them, with an increasingly partaking and central role, there are the consumers. Hence, innovation is more and more a 'collective enterprise that needs the effort of many entrepreneurs, both in the public and private sectors' (Van de Ven et al. 2008). Furthermore, the strong cognitive component, which is at the base of competitiveness, bridges innovation to internationalization. The latter is increasingly a process of transnational dissemination of knowledge, in which enterprises should be able to fit in and seize opportunities for development.

Many scholars relate the Italian SMEs lack of competitiveness to the so-called 'size issue.' Several endogenous and exogenous reasons, but also the Italian entrepreneurs culture, characterized by autonomy and individualism (del Junco and Brás-dos-Santos 2009; Hofstede G. 2001) have made difficult for SMEs to grow in size, especially when it comes to mergers or acquisitions.

However, as pointed out by Ricciardi (2008): 'the small size is no longer an intermediate stage compared to the large company, but an independent phenomenon triggering alternative development paths to grow in size.' This is backed by the principles outlined in the European Small Business Act (think small first), but also at the industrial level with the with the new 'Makers' phenomenon (Anderson 2013).

According to Furlan and Grandinetti (2011) SMEs growth has to be realized in a multidimensional way. First, the SMEs have to improve the relational capabilities, making efficient and effective the use of the existing relationships and expanding the network of relationships ('relationship growth'). Then, SMEs ought to increase knowledge and capabilities needed for innovation purposes, becoming more capable in revising products, processes and organization ('capability growth'). Relationship growth and capability growth are tightly connected to the absorptive capacity, a key dynamic capability for boosting SMEs' innovation processes and competitiveness, as it expresses their ability to acquire, assimilate, transform and exploit external resources (Zahra and George 2003; Cohen and Levinthal 1990; Liao, Welsch, and Stoica 2003; Noblet, Simon, and Parent 2011).

As demonstrated by the success of SMEs in Italian industrial districts, a solution based on relational assets lies in network cooperation, representing an alternative to short-term growth (Rullani 2003). According to Rullani (2003): 'the competitive strength of a firm depends not so much on its size as an isolated company, but by the size of the networks to which it belongs, and by the efficiency of their channels in transferring knowledge.'

Networks allow companies: to adopt a global orientation searching for new opportunities and knowledge; to take advantage of external specializations and focus more on what they excel; to differentiate knowledge and skills in various fields; to benefit from various types of economies and cost reductions; to share with other entities, investments (and associated risks) in new technologies, marketing strategies; to disseminate new standards and launch new technologies on the market; to enter into international markets easily and quickly; to collaborate without difficulty with public and private entities that are essential to create innovative and customer relationship based business models; to be part of multi-sectorial alliances that, thanks to knowledge sharing, allow to implement highly complex innovations; to use human capital more effectively and more efficiently (Gulati et al. 2000; Rullani 2006; Ahuja 2000; Capaldo 2007; Johanson and Vahlne 2009; Oviatt and McDougall 2005; Bell, McNaughton, and Young 2001; Van de Ven et al. 2008; Parolini 1996; Russo 2011; Ricciardi 2013).

With the changing of environmental dynamics, the district is losing its competitive advantage, even though it is still important for the Italian productive system (Ricciardi 2013).

Especially for Italian SMEs, modern innovations and internationalization processes require networks that are: stable and governed; equipped with effective knowledge sharing mechanisms; based on the participants' sense making, extended in terms of 'cross-sectorial' and 'cross-territorial' dimensions (networks designed in order to exploit both global and local opportunities) and developed selecting carefully partners and their competences (Dyer and Singh 1998; Powell, Koput, and Doerr-Smith 1996; Ricciardi 2013; Rullani 2006).

After a description of the CR and its characteristics, we propose it is an innovative tool, which supports the management of the above-mentioned networks and then improve the competitive performances of participants (the Italian SMEs). As of 1st March 2015, there were 2.012 CRs, involving more than 10.000 enterprises (see http://www.infocamere.it). Figure 1 shows the number of CRs from 2010 to March 2015.

Literature Review

The Contratto di Rete as an Innovative Tool: A Multidisciplinary Analysis

The law decree 5/2009 and its subsequent integrations introduced the Contratto di Rete in the Italian legal system. According to it:

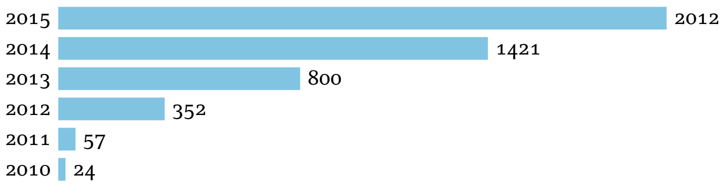

FIGURE 1 Number of CRs from 2010 to March 2015 (based on data from http://www.retimpresa.it and http://www.confindustria.it)

'through the CR, a group of entrepreneurs aims to accrue, individually and collectively, their innovative capacity and their competitiveness on the market. In order to fulfil their aim, they commit themselves: 1) to cooperate in forms and fields fitting their business activities; 2) to share industrial, commercial, technical or technologic knowledge or services; 3) to carry out together one or more activities convenient with their business activities.'

A relevant literature defines the CR as 'a multilateral contract with a shared purpose' (Cafaggi 2010a; 2010b; 2011; Gentili 2011; Guerrera 2012; Maltoni 2011; Villa 2010a; 2010b; Arrigo 2014), where the shared purpose lies in increasing the innovation capacity and competitiveness of the members and the network itself.

From a legal point of view, it is a formal contract with mandatory effects, in the sense that each member has to fulfil the collaborative duties set out in the common program and has the right to require the other members to do the same (Camardi 2009).

The law indicates the essential elements of the CR:

- The group of participants (only Italian single entrepreneurs, companies, cooperatives and Consortiums can participate to the CR);
- The strategic goals and their assessment system;
- The program, specifying rights and duties of the members and the planning to fulfil the aim of the CR;
- The length of the partnership (according to Unioncamere, see http://www.unioncamere.gov.it, more than one third of the CRs plan to last more than 10 years);
- The enter conditions for new members;
- The decision making rules on topics of common interest.

The CR can include the creation of a common fund and the establishment of a central governance board, which manages the execution of the contract in behalf of the members. Although these last elements are voluntary, most of the CRs include them. At present, also the attribution of legal subjectivity is optional. The contract alone configures a network called 'Rete Contratto.' Members can transform it into the so-called 'Rete Soggetto,' which is an autonomous legal entity.

The CR allows enterprises to formalize their collaboration. First, formalization is important for the purpose of enforceability against third parties and relevant stakeholders that can interact with an established and institutionalized entity. The CR has also an important role in terms of internal control without making the cooperation too rigid. Members can easily modify the contract, including new clauses and rules.

As stated before, Italian SMEs need more stable and managed networks in order to develop their competitiveness. At the same time, the strategic behaviour of Italian entrepreneur is tightly connected to individualism and autonomy (Ansoff 1987). The CR could provide an innovative answer balancing these two needs. The CR is a broad frame that the members can customize in autonomy, according to their cooperation needs. Moreover, the identities of the members are safe. The lawmaker designed only a broad frame that the members can customize with their own intentions (Cafaggi 2010a). The CR discipline is 'purposely essential' conceiving the same as a 'work in progress' that is completed and modified while used by the members.

Another strength of the CR is its strategic coordination function. The program acts as a platform for stimulating the dialogue among the members. Strategic objectives, the rights and the duties of the members, the definition of the roles and behavioural rules, the planning and control tools are other elements from the CR program that play a central role in enhancing the cooperation among the network participants.

Formalizing the program and the objectives is fundamental for institutionalizing the collaboration and sense making processes among the members (Ring and Van De 1994). The objectives, the roles and the rules, the responsibilities, the mechanisms regulating integration and mutual expectations, the communication channels, the standards and languages (required to best operate) are all elements that funnel the actions of the members in a strategic way (Mellewigt, Madhok, and Weibel 2007; Gulati, Wohlgezogen, and Zhelyazkov 2012; Mayer and Bercovitz 2008; Argyres, Bercovitz, and Mayer 2007). Consequently, each member knows exactly its role, tasks, rights and duties within the network and configures its position conveniently with its resource and competences. In addition, the CR is a learning tool to understand what is not working in cooperation. As collaboration problems are resolved, CR gradually incorporates the solutions and codifies the parties' knowledge about efficient ways to collaborate (Mayer and Argyres 2004).

The possibility of considering a long-term oriented programming is what differentiates the CR from other aggregation forms. Both the ATI (Temporary firms' aggregation) and the Consortium are purpose related aggregations. Their scope is limited to the achievement of a particular target and the management of specific operations. In particular, the CR is different from the ATI in structuring a lasting alliance, with the specific purpose of increasing the competitiveness (innovation, internationalization, etc.) of the members. ATI is usually involved in public contracts' participation. Enterprises (usually of the same sector) create Consortiums typically for achieving scale economies and cutting costs related, for example, to R&D activities, without a shared competitive target. This does not mean that the CR is opposed to 'natural' networks, non-formal aggregations or the usage of above-mentioned tools. Instead, it contributes to enhance the cooperation already existing within such systems, making it more effective (Ricciardi 2013).

Trust, reputation and professional reliability are critical assets in the internal dynamics of the CR, considering its orientation to the long term and its focus on shared objectives (Larson 1992; Dyer and Singh 1998; Granovetter 1985). In particular, trust is a central mechanism of 'cognitive coordination' which determines the knowledge flows among the members (Lorenzen 2001, 16). Such interactions create the conditions for the 'social capital' to emerge, making the processes of knowledge sharing easier and fostering once again innovation and internationalization (Nahapiet and Ghoshal 1998). In the case of SMEs, interpersonal trust is even more important, as the innovative potential is strictly related with the entrepreneur's personal networks (Ahlin, Drnovsek, and Hisrich 2014).

Research Question

Taking into account the above-mentioned characteristics of the CR, our research question is the following:

Q1 *Is the* CR *an innovative tool for supporting the creation of networks where Italian* SMEs *can improve their competitiveness?*

Methodology

To answer our research question, we adopted a multiple case study design (Yin 2009) with the aim of analyzing the competitive improvement realized by SMEs since they entered in the CRs. The four CRs analyzed regard various sectors and have at least two years of operation in order to obtain more reliable results (data from regular monitoring of the Italian Camera di Commercio reports). We selected and described some cases whose experience has shown higher managerial and organizational implications (Eisenhardt and Graebner 2007).

We adopted a longitudinal perspective to observe how events unfolded over time (Langley et al. 2013; Langley 1999). We administered semi-structured interviews to business owners, which are the main responsible for strategic decisions in SMEs (Johannisson 1988; Desouza and Awazu 2006; Ahlin, Drnovsek, and Hisrich 2014). Data collection in a longitudinal sense was achieved through follow-up interviews and mail updating for a period of at least 2 years (Langley et al. 2013; Langley 1999). For each case, we collected interviews from different point of views (CR President, CR Manager, etc.), assuring the validity and coherence of information (Wellin 2007). Finally, we triangulated data with relevant internal documents provided by the interviewees, such as reports, presentations, brochures and legal documents.

Following Yin's (2009) suggestions, we maintained a database of all the recorded interviews, transcripts and notes. Recording is a standard practice in all qualitative interviewing (Hermanowicz 2002) as it also includes paraverbal attributes such as pauses, intonation, laughter. Those details help the researcher to understand the production of meanings by the interviewee. Each interview regarding the business owners lasted on average 45 minutes, covering as general topics: a brief presentation of the interviewed (SME business owner); the motivations that led the entering inside the network and subscribing the CR; the role of the enterprise inside the CR; the types of relationships eventually existing with other members of the CR; the processes of negotiation and formalization regarding the governance structure, the partners selection, the programming, the roles and the rules; the cooperation dynamics that are growth inside the CR; the processes of knowledge sharing and absorbing experienced by the enterprise as a member of CR; the new partners acquired by the enterprise after the entry in the CR; the joint activities and investments with other members developed by the enterprise in the CR; the effects of the CR on the sense making and coordination processes; the results that the CR provided in terms of innovation, internalization, marketing and commercialization; the difficulties experienced by the enterprise in the CR dynamics.

TABLE 1 Summary of Case Details

CR	Number of participants	Sector	Focus	Program
Calzatura Italiana	7	Footwear	Innovation	Development of an environmentally friendly shoe sole, creating a new safety shoe addressed for military use.
Crisalide	3	Green/ clean tech	Innovation	Development and commercialization of SOFC fuel cells with an innovative business model.
Almax	8	Textile/ fashion	Innovation/ marketing	Protection and evolution of the local cultural heritage related to leatherworking through networking synergies.
Massafra Industrial Group	4	Mechanic	Internationalization	Providing a complete proposition to international customers.

Findings

CALZATURA ITALIANA

The CR 'Calzatura Italiana' was born in 2011 in conjunction with a project aiming to develop new materials for shoe safety and in particular responding to the need of producing a military boot. The CR arises from the desire of connecting different skills and knowledge, developing new innovative projects and willing to internationalize.

The participants to the network are Eurosuole Joint Stock Company, Elettromeccanica Pantanetti Limited Partnership and Calzaturificio London Limited Liability Company, Formificio Enzo Limited Liability Company, Infor-ma limited liability Company, Tacchificio Ares Limited Liability Company and Josephine Limited Liability Company (start-up created inside the CR). The network has designed and manufactured safety and military shoes with high technology soles. These soles are multimaterial and environmentally sustainable with a high customization.

As it is possible to note from table 2, we have many enterprises participating to the Calzatura Italiana. The seven local companies participating to the Network belong to the shoe industry and form a wide vertical chain.

CRISALIDE

The CR 'Crisalide Net' born in 2011 is a network of company operating in the clean energy sector, located in the BIC (Business Inno-

TABLE 2 Members of the CR Groups

Calzatura Italiana	Crisalide Net	Almax	Massafra Industrial Group
Eurosuole, Elettromeccanica Pantanetti, Calzaturificio London, Formificio Enzo, Infor-ma, Tacchificio Ares, Josephine, University of Marche	Electricity Producers, Primiero Oil Free, Municipalities Consortium, Provincial Energy Agency (APE), ENAIP, Trento University, Mach Foundation, Habitech Trentino, SOFCpower, Dolomiti Energia, Trillary, Algorab, Trentino Network, Trilogis, Confindustria Trento	Almax Pelletteria, Pelletteria Vittoria, Nanni Pelletteria di Allocca Massimiliano, Beccattini Giovanni, Samar di Monteleone Salvatore, Pelletteria Demipelle di Grazia Maria Laura, Miranda Bernardo, Pelletteria Anna	Stoma Engineering, Modomec, Rima Fluid, Elsac Engineering

vation Centre) of Mezzolombardo Trento runned by Trentino Development. It arises in the wake of the project Crisalide, which aims to develop, the innovative technology of the micro combined heat and power or also known as micro-CHP with Solid Oxide fuel cell (SOFC) technology. Three local companies make up the network: SOFCpower joint stock Company, Dolomiti Energia joint stock Company and Trillary limited company. The network is composed by, the President, the vice-president and the board meeting. The members created a common fund and common body.

The project Crisalide is an industrial supply chain initiative promoted by the companies participating to the CR and from a special collaboration with Habitech Trentino – Energy and Enviroment Cluster. Many other entities coming from different sectors, participate to the supply chain like plant design, energy conservation, university and professional institutes with high-level international references. SOFCpower Joint stock is an Italian excellence in SOFC technology. Inside the network it takes care of the scientific R&D. Dolomiti Energia Joint stock company is one of the most important Italian multi-utility. Within the network, it deals with corporate governance and management consultancy, linking the technology to market needs. Trillary is a spin-off of the Crisalide project, born shortly before the creation of Crisalide Net. Inside the network, it deals with the production of software, consultancy and other ICT related activities.

ALMAX NETWORK

Almax Network was born in 2011 in the leatherwork district of Scandicci, Tuscany. It includes eight SMEs, whose leader is Almax Pelletteria, a firm established in 1986. Its management board has appointed an external Network Manager and established a common fund. The Network total turnover is over 100 million euro.

The network's broad aim is to enhance the competitive power and the innovative capacity of the members through the exchange of resources, knowledge and competences. Nevertheless, Almax Network has a more specific target that is the protection of the local cultural heritage related to leatherworking.

Indeed, Tuscan leatherworking is worldwide famous because of its superior design and quality, achieved through a distinctive set of skills developed by artisans over the centuries. The district model, characterized by numerous and small handcrafters, has always guaranteed such differentiating features, but is now suffering from lack of innovation and competitiveness: in 2009, its turnover decreased by 40%, inducing many SMEs to go bankrupt. Almax Network aims at protecting this traditional business model, allowing its evolution without betraying its original spirit and dynamics.

Almax Network is part of a bigger network-of-networks, which includes 6 CRs, sponsored by the prominent manufacturer Gucci. The Maison believes that its competitive advantage lies in exclusive relationships with local highly skilled artisans. For this reason, Gucci is supporting the development of a stable and organized supply network endowed on one hand with the local and traditional craftsmanship, and on the other hand with modern and innovative dynamics. Almax is cooperating with Gucci's CSR department in order to meet their business ethics requirements in terms of social equality and inclusion, health and safety, environmental protection, energy saving and good practices.

MASSAFRA INDUSTRIAL GROUP

Massafra Industrial Group (MIG) is a network established in 2012 in Puglia, connecting four firms – Stoma Engineering, Modomec, Rima Fluid and Elsac Engineering located in Taranto, Bari and Massafra.

MIG network operates in the metallurgical industry, combining the offerings of the four firms in order to provide a complete proposition to the customers. Indeed, the core competences of MIG include mechanics for realizing iron and steel engines; carpentry, industrial plants; oil-pneumatics; for enlivening industrial engines and plants; automation of industrial plants.

The Italian metallurgical industry has been suffering heavily the impact of the economic crisis: the national mechanical production decreased by 38% since 2008 (http://ec.europa.eu/eurostat). To face this dreadful setting, the overarching strategy of the group is to develop the international dimension of their business. The CR allows the member firms to integrate their specific competences, overcoming the limits related to their dimensions as single units. The group boasts 30.000 square meters of factories and competences to operate in the metallurgical, oil and chemical, energy and aeronautical industries.

Moreover, the networking model is providing the members with two sets of strategic advantages. First, the group has attained the minimum dimension to contract directly with big customers, allowing the firms to evolve from their initial status of subcontractors. Second, non-internationalized members, such as Elsac Engineering and Rima Fluid, took advantage of the experience and international relations of the other partners who already operate globally. In this sense, the CR fostered the sharing of information and contacts related to foreign markets, overcoming the liability of foreignness.

In particular, MIG is today operating in Brazil, Morocco and Russia. In Brazil, Stoma Engineering acquired a contract for realizing a lift bridge. Hence, together with Modomec and Elsac Engineering, they established a local subsidiary in order to carry out the project. In Morocco, MIG has a commercial office to acquire contracts from local customers. Finally, the network is building a strategy to enter in the Russian market, where the metallurgical industry is attractive and distinctive competences are required.

Extracts from the Interviews to the Business Owners

CALZATURA ITALIANA

'Thanks to the network it was possible to develop materials and products which are now part of the competencies of all the companies participating to the network. It is always more important to work in-group and make a critical mass by entering in a network. The product that the network develops need to be internationalized, especially operating in the logic of a network that brings different benefits.'

'The contract has given us the possibility of formalizing existing

TABLE 3 Summary of the Competitive Improvements for the Members

CR	Relationship improvements	Size improvements	Capability improvements
Calzatura Italiana	The members institutionalized existing cooperative relationships (vertical relationships) in the local industrial district. The members engaged with large enterprises and public administrations.		The members improved their coordination and shared knowledge on product innovation processes. The members patented their innovations.
Crisalide	The members transformed existing institutional relationships (in the local industrial district) in a cooperation with innovative purposes. The members institutionalized their collaboration (as a means to make sense). The members engaged with foreign enterprises, large enterprises, universities, public administrations, vocational training schools and international institutions.	The members created a new spin-off. The members received external funds for supporting network activities.	The members improved their coordination and shared knowledge on product innovation and commercialization. The members patented their innovations.
Almax	The members transformed existing competitive relationships (in the local industrial district) in coopetitive ones. The members institutionalized their collaboration (as a means to make sense). The members engaged with large enterprises and banks.	The members acquired new technologically advanced equipment.	The members improved their coordination and shared knowledge on product innovation processes. The members improved the efficiency of their value chain, developing functional capabilities.
Massafra Industrial Group	The members formalized existing coopetitive and institutional relationships in the local industrial association. The members institutionalized their collaboration (as a means to make sense). The members engaged with international markets, foreign enterprises and large enterprises.	The members created subsidiaries and commercial offices in foreign countries. The members received external funds for supporting network activities.	The members improved their coordination and shared knowledge on internationalization processes.

relationships. The network increases future growth reaching competitive advantage.'

CRISALIDE

'We have a strong interest in bringing the technology outside the development phase, and so reaching the market. Relations of friendship, of context and proximity are favouring the success of the CR. The innovation that comes from our activities is not only technological, but allows our partner to build a new business model, offering new services and contractual forms to the customers.'

'The goal of the network is to invest in innovation. The initiative has catalyzed a complete local supply chain all around the innovation of micro-CHP fuel cell SOFC. We want our territory to be at the pole position in Europe and worldwide regarding this technology.'

ALMAX

'Achieving a critical mass is a key requirement for seizing the opportunities that eventually drive our growth. Having a critical mass means owning significant assets and bargaining power. The CR brings these elements together, creating a unique body without limiting our single identities. For third parties, we are a group of eight firms with a turnover of roughly 100 million euro. Still, we keep our autonomy safe, thanks to the CR. The network speeded up our research activities. We introduced a standardized best practice system, a rationalization of the business processes, and new production methodologies. This was possible through knowledge sharing and the availability of resources to acquire new technologically advanced equipment, which was too expensive when we were not in the CR.'

'CR membership brought us new work opportunities, as well as new challenges to face. We entered in Gucci's supply chain thanks to our skills and the trust we built over time. We have the chance to distribute the tasks among the members, so that we can specialize in our area of excellence. Networks are useful to give SMEs the same opportunities of larger firm.'

MASSAFRA INDUSTRIAL GROUP

'Global markets seek complete technological solutions for their problems. The critical point is providing a multi-products offering, rather than competing on price. Without this, we would only work as subcontractors. We should not be afraid of working with big multinationals. We have a strong and complementary network. The network allows us to obtain new orders, while we keep working with our own customers. This is CR's main advantage.'

'Entering in new markets is much easier through cooperation. As single firms we are not as strong as Ilva or Eni, but as a group of firms we can do lot on both the international and local market. The group leverages on each firm commercial network.'

Discussion

The SMES can overcome the difficulties related to the 'size growth' adopting a holistic approach focused on networking and other two types of growth, which are very important for innovation and internationalization purposes: the 'relationship growth' and the 'capability growth.'

Our findings show how the CR is supporting these growth processes for the members. Coherently with the Italian entrepreneur needs of flexibility and independence, the CR sustains over time cohesion, coordination and learning, in relation to strategic long-term goals (innovation, internationalization, commercialization, etc.) that otherwise would be difficult to achieve independently.

First of all the CR empowers sense-making processes and, consequently, enables participants: to create a common ground and construct accounts; to increase mutual understanding; to reduce cultural resistances and the levels of ambiguity and uncertainty; to focus the attention on core activities and decisions. Moreover, the CR works as coordination tool that is essential for partners' knowledge sharing and absorbing (e.g. ALMAX). Absorbing knowledge and capabilities form different sectors, SMES can obtain innovative products and processes, as well as more competitive business models (e.g. Calzatura Italiana and Crisalide).

In terms of internationalization, the CR provides the participation in international networks and speeds up the global relational growth (e.g. Massafra Industrial Group). Moreover, the CR acts in global markets as a unique player, with an increased bargaining and competitive power, enabling processes of cognitive internationalization, raising the exchange of flows of knowledge and resources with foreign actors (clients, large enterprises, universities, etc.).

Conclusion

Integrating legal and managerial perspectives, the present study illustrates to academics, managers, entrepreneurs and public administrators how in Italy there is a new way for creating, sharing and absorbing knowledge through a network: the 'Contratto di Rete.'

This exploratory study calls for an empirical and quantitative deepening to test further its propositions. However, from a legal point of view, it is possible to affirm that the CR is an innovation of the Italian legislature in relation to the 'Economy of networks' (Arrigo 2014). In addition, the European Commission found the CR very innovative and in line with the principles contained in the Small Business Act (SBA). Indeed, it is considering a European version of the CR. From a managerial point of view, our findings show that the CR is effective for the competitive performance of the involved enterprises, transforming them in 'real players' ('a firm grows by being a player; it does not become a player by growing'; Powell, Koput, and Doerr-Smith 1996).

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Framework of Strategic Learning: The PDCA Cycle

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Nowadays, strategic planning has to be permanent process and organizational learning should support it. Researchers in theories of organizational learning attempt to understand processes, which lead to changes in organizational knowledge, as well as the effects of learning on organizational performance. In traditional approach, the strategy is viewed as one shot event. However, in contemporary turbulent environment this could not be still valid. There is a need of elastic strategic management, which employs organizational learning process. The crucial element of such process is information acquisition, which allows refining the initial version of strategic plan. In this article authors discuss the PDCA cycle as a framework of strategic learning process, including both single-loop and double loop learning. Authors proposed the ideas for further research in area of organizational learning and strategic management.

Key words: PDCA cycle, organizational learning, knowledge, strategic management

Introduction

Knowledge is seen as a critical organizational resource that provides a sustainable competitive advantage in a competitive and dynamic economy (e.g., Davenport and Prusak, 1998; Drew 1999; Foss and Pedersen, 2002; Grant 1996; Huang 2009; Lin 2007; Spender and Grant 1996; Wang and Noe 2010; Wen 2009; Xu and Bernard 2011). Particularly important is to identify potential knowledge gaps needed to create successful strategy (Zack 1999). Strategy planning is an information-intensive process, and as Makadok and Barney (2001) notice, 'It is, in many ways, ironic that research in the field of strategic management has proceeded for so many years without a theory of information acquisition.' The issue of information acquisition should attract as much attention as the strategy formulation process itself (Makadok and Barney 2001).

Organizational learning denotes a change in organizational knowledge. Theories of organizational learning attempt to understand the processes, which lead to changes in organizational knowledge, as well as the effects of learning and knowledge on behaviours and organizational outcomes. Argyris and Schön (1978) distinguished between single-loop and double-loop learning. In single-loop learning, individuals, groups, or organizations modify their actions according to the difference between expected and obtained outcomes. In double-loop learning, the individuals, groups or organization question the values, assumptions and policies that led to the actions in the first place. If they are able to view and modify those, then second-order or double-loop learning has taken place. In this article authors discuss the PDCA cycle as a framework of strategic learning process, including both single-loop and double loop learning.

Organizational Learning

The learning theory is mostly inspired by an individual-oriented psychological field (Brandi and Elkjaer 2011, 26). Information processing and decision making in organizations are seen as something that is done by individuals, and processes that can be enhanced by individuals' learning. Individuals' learning outcome can then, by way of individuals' acting on behalf of an organization, be crystallized in organizational routines and values and become organizational learning. The idea is that individuals hold a mental model in their mind, which is an abstract representation of their actions. It is a mental model, which can be enhanced in order for individuals, and subsequently organizations, to reinforce information processing and lead to better decision making in organizations.

The idea, that an organization could learn was described by Cyert and March (1963). They presented a general theory of organizational learning as part of a model of decision-making within the firm and emphasize the role for rules, procedures, and routines in response to external shocks and which are more or less likely to be adopted according to weather or not they lead to positive consequences for the organization. They also presented the early version of the distinction between single and double-loop learning 'An organization [...] changes its behaviour in response to short-run feedback from the environment according to some fairly well-defined rules. It changes rules in response to longer-run feedback according to some more general rules, and so on' (Cyert and March 1963). The book written by Agryris and Schön (1978) was very important since it laid out the field as a whole very clearly and their distinction between organizations with and without the capacity to engage in significant learning. At the beginning, the theory was connected with adapting to changing environment and to provide prescriptive managerial techniques, later the learning organization has proved to be a powerful concept for organizational development (Agryris and Schön 1996; Pedler and Aspinwall 1998; Senge et al 1999).

Senge (1990) states that it takes five components to establish a learning organization – personal mastery, mental models, shared vision, team learning, and system thinking. What distinguishes learning organization from non-learning organizations is their focus on these five disciplines. Another normative modeller (Garvin 1993) claims that learning organizations are skilled at systematic problem solving, experimentation, learning from their own experiences and from others, and transferring knowledge.

Strategic Management as a Learning Process

According to Drucker (1974), strategy is 'purposeful action.' Strategy is also understood as long-range planning (Porter 1979). Strategy is defined as a unified, comprehensive, and integrated plan designed to ensure that the basic objectives of the enterprise are achieved (Xu and Bernard 2011). Strategy planning is an information-intensive process, which gathers data regarding both the organization and its environment, filters them, and interprets them in order to make strategic decisions (Makadok and Barney 2001). Strategy concerns with the future, which is uncertain. Traditionally the efforts in strategic planning are focused on eliminating this uncertainty by engaging experts whose are assumed possessing an extra knowledge. Strategic knowledge acquisition is a key element of creating superior performance – both on the company and on the business unit level (Pietrzak at al. 2015).

However, in practice, there is no any perfect knowledge during strategy formulation available. This causes the uncertainty and undermines the assumption of the pure rational model of decision-making. Idea of one-shot the best answer is replaced by concept of continuous and gradually development of strategy. As van der Heijden (1998) claims – since we agree that the uncertainty exists – the key to success became not one-shot elaboration of the best strategy but effective continuous process of designing strategy. Such process requires permanent strategic conversation. Putting uncertainty in strategic equation reframed strategic planning from single episode into permanent learning. It could be seen as organizational learning. This reasoning could be summarized by remark attributed to

Eisenhower: 'plans are nothing; planning is everything' (Cowley and Domb 1997).

Process of creating strategy must be iterative. Creation of the strategy is built on assumptions. According to the uncertainty and lack of perfect access to the information, such assumptions are not perfectly correct. The ultimate test for them is implementation of the strategy. During the process of the strategy execution, some opportunities could disappear while others arise and some action plans could become impossible, while others could become viable. In the consequence, an initial strategy may have to be modified (Peel 2012). How to organize strategic management process viewed in such way?

It seems that the PDCA cycle developed under Total Quality Management umbrella could be considered as a handy and useful model to frame such process. Nevertheless, the PDCA framework was originally developed by quality control movement, its application has not to be limited – in fact, it is a learning method (Cowley and Domb 1997; Maruta 2012). The feature of PDCA scheme is that it consists of both single and double loop learning – according to Agryris and Schön concept (1978). This feature is crucial for effective organizational learning during strategic management process.

Strategic Learning Process Framed on the PDCA Cycle

The PDCA (plan-do-check-act) is an iterative four-step cycle used primarily as a scheme of quality improvement process. However, in fact it could be used as a framework of any management process, in this number – strategic management process. For example, Hoshin Kanri (Policy Deployment) – Japanese method of strategic management is based on the plan-do-check-act cycle (Cowley and Domb 1997; Babich 2002; Akao 2004). The plan-do-check-act cycle is also referred in the strategic management concept based on Balanced Scorecard (Kaplan and Norton 2008).

The PDCA cycle is commonly named as Deming or Shewhart cycle. Deming popularized PDCA during his lectures about quality control methods for Union of Japanese Scientists and Engineers in 1950s. PDCA was immediately applied in Japan under Deming cycle name. However, Deming always referred to it as the Shewhart cycle according to his mentor in quality control – Walter Shewhart. What are the origins of the PDCA cycle? There are two main opinions presented. The first one draws the roots of this concept from 17th century and the modern scientific method developed by Francis Bacon. Up to his times, science depended on deductive logic to interpret nature. Bacon proposed inductive reasoning – from observations to axiom

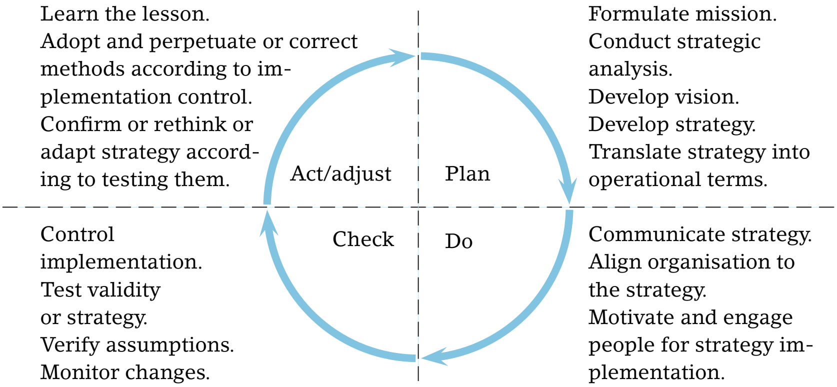

FIGURE 1 Strategic Learning Process Framed on the PDCA Cycle

and to law. His method can be expressed as hypothesis-experiment-evaluation and could be reformulated into plan-do-check-act (or adjust) cycle. The second opinion places the origins of PDCA in John Dewey work on education. Some authors mixed these both opinions – treating Dewey work as based on inductive method of Bacon (Cowley and Domb 1997; Babich 2002; Moen and Norman 2010; Maruta 2012).

Broniewska (2007) links the PDCA to the cycle of organized management formulated at the beginning of 20th century by Henry Le Chatelier. Le Chatelier's cycle is based on idea of using science for better organization and consists of five stages: (1) select objective – (2) study means and circumstances indispensable for achieving objective – (3) prepare means and circumstances as needed – (4) do according to the plan – (5) check the results (Le Chatelier 1926).

The stages of the PDCA cycle could be interpreted as follows (compare: Cowley and Domb 1997; Babich 2002; Moen and Norman 2010; Maruta 2012):

- P *Plan* what you want to accomplish and define how you will know when it is accomplished. Do not proceed without a plan. Determine objectives (expressed in the measurable form) to be reached and methods to achieve them;
- D *Do* what have been planned. Carry out the test by implementing the methods according to the plan;
- C *Check* how well you accomplished the expectations. Observe the effects. Examine the results achieved. Are the objectives from the plan reached? Look for the possible deviation from the plan; Test the plan accordingly to the information gained during the

cycle. Is the reasoning underlying the plan still valid? Were any changes occurred?

- A *Act or Adjust.* What lessons could be learned from the cycle? Adopt and perpetuate methods, which were successful in reaching objectives. If not determine the root causes and correct the implementation. Is it reasonable to continue the plan? Are any adjustment needed in plan for the next cycle? Should the plan be adapted or rethought?

The circle goes round and round – the fundamental principle is iteration. By repeating the cycle the plan is confirmed or negated, our knowledge is getting richer, and process managed on the PDCA framework is continuously improved.

Originally, the Deming cycle was developed in manufacturing, however its application has not to be limited to the quality control issues. The PDCA cycle is in fact a learning method (Cowley and Domb 1997; Maruta 2012). According to the previous discussion about the need of strategic management conducted as continuous process of organizational learning – the PDCA cycle could be useful as a framework of such process. Figure 1 presents process of strategic management viewed as a permanent learning cycle framed on the plan-do-check-act scheme.

Plan Stage of Strategic Learning Process

The mission is a statement defining why the organization exists. The vision defines the three- to ten-years goals of the organization. As opposed to the mission, which remains fairly stable over time-vision sets the organization in motion and drives the actions to the desired future (Babich 2002; Kaplan and Norton 2004). Vision is usually expressed in visionary terms and it should be stretched; however, it has to be also achievable and grounded in the real possibilities. This is why vision and strategy should be developed after conducting strategic analysis. Strategy means a choice of a set of activities in which a company wants to operate at a superior level in order to create a greater value to targeted customers and to create a sustained advantage over its competitors (Porter 1996). To make strategy actionable it should be expressed in operational terms what means translating strategy into objectives and measureable targets (Kaplan and Norton 2001). Measurability of strategy allows assessing the progress in the fulfilment of organization mission and in reaching its vision and is an important premise of the success of the strategy implementation. Monitoring strategy execution is highly complex task. Anything is much easier to control if it is reduced to quantifiable measures (White 2004). According to the concept of double-loop learning of Agryris and Schön (1978) strategy could be seen as the theory which steers of actions done (Kaplan and Norton 1996; 2001; Steinmann and Schreyögg 2000) – compare figure 1, stage Plan.

Do Stage of Strategic Learning Process

Putting strategic plan into day-by-day practice is based on the three pillars: communicating and educating about strategy, setting goals and linking incentives to strategic performance measures (Kaplan and Norton 1996) – compare figure 1, stage Do.

Implementing the strategy should begin whith education of those people who are engaged in strategy execution – to make it a part of their everyday job (Kaplan and Norton 1996). Any novel idea or change – even if it is of the high quality – require acceptance from those who are responsible of bringing it to life out. Otherwise, its potential value will never be realized. This rule could be expressed in an equation popularized by Steve Kerr: 'Quality' times 'Acceptance' equals 'Effectiveness.' To gain acceptance for the strategy it must be communicated. Before managers and employees can execute the strategy, they must accept it. In order to accept the strategy employees must understand it, what could be reached by communication and education (Niven 2005). Organization could use many diversified channels of communication, such as distribution of brochures or newsletters, holding meetings, posting bulletin boards, groupware and electronic bulleting boards etc. The basic aim of them is to win both the hearts and minds of the employees for engagement in the strategy implementation (Kaplan and Norton 1996; 2001).

The next pillar is aligning the various component parts of the organization in one line with the strategy. This activity is particularly important in the bigger firms, which consist of multiple businesses and support units. The challenge is to synchronize the various component parts of such organizations to create integration and synergy. The crucial mechanism of alignment is cascading of strategic goals into lower levels of the company hierarchy (Kaplan and Norton 2006).

Important factor of strategy implementation success is also creating link between strategy and motivation system. There is a quite common belief that incentives could be used to increase motivation. At least incentives tend to increase the focus of employees (Niven 2008). There are two possibilities to link incentives with the strategy – an explicit connecting with the strategic targets, formula-based system or to allow executives to set rewards subjectively basing on own evaluations of the employees' engagement in strategy implementation (Kaplan and Norton 1996). Besides of such forms of compensation it should be stressed the role of intrinsic motivation, which is associate with commitment in entrepreneurial and creative behaviour. Managers can create intrinsic motivation by appealing to people's need to work for a successful organization that makes a positive contribution to the world. The key form of addressing such desire is communication of mission, vision and strategy (Kaplan and Norton 2006).

Check Stage of Strategic Learning Process

Strategic management needs to be controlled as any other managerial process. It should be stressed that strategic control should consist of several forms of controlling activities. Steinmann and Schreyögg (2000) differentiate three types of strategic control: implementation control, premise control and strategic surveillance – compare figure 1, stage Check.

Implementation control should consist of monitoring strategic thrust and milestone review (Jeyrathnam 2008). To control strategic thrust means monitoring progress of strategic actions. Milestones are critical points in strategy implementation or mediatory goals on the strategic trajectory (Steinmann and Schreyögg 2000; Jeyrathnam 2008). Thus, milestones review could be interpreted as monitoring of targets accomplishment. At the check stage, any deviations from course of action and established targets should be register. It is important do not focus attention only on ex post checking (feed-back) but also to predict any difficulties what allow to take counter actions in advance (feed-forward).

However, in contemporary circumstances of complex and turbulent environment, organizations conducting their strategies have to cope with uncertainty. Strategies are built on premises, which are never perfectly correct. In such context strategy should be treated as a clear view – based on the available knowledge and defensible assumptions – of what it seems possible to reach within a given set of constraints. As the knowledge and circumstances changes – it is possible and even should be facilitating to change strategy if needed (Kaplan and Norton 1996; Steinmann and Schreyögg 2000; Peel 2012). Strategies may seems be valid when they were defined and launched, in the sense that they are built on the best available evidence. However, test of the implementation in the real world and the new knowledge captured could undermine the validity of strategies. As Kaplan and Norton pinpointed, business conditions are changing (1996). New chances and threats arise constantly while others disappeared (Kaplan and Norton 1996; Peel 2012).

Besides of uncertainty and complexity bundled with strategic decision, planning requires unequivocally for recommending any direction of actions. Thus planning artificially reduces uncertainty and complexity. Continuous validation of strategy is needed in order to balance the risk generated by such reduction. 'The purpose of premise control is to monitor regularly whether the assumptions underlying a strategy generated during the time of formulation are valid [...] if these assumptions are not valid there is a need to change the strategy to make it effective' (Jeyrathnam 2008). Strategic surveillance is undirected form of strategic control. Task of strategic surveillance is generalized and overarching monitoring of organization and its environment looking for possible events which are likely to threaten the strategy. In other words, this is watching symptoms of crisis of the strategy (Steinmann and Schreyögg 2000; Jeyrathnam 2008). Those both form of control described above allow to test validity of strategy by verifying underlying assumptions and by monitor changes which threatening it.

Act/Adjust Stage of Strategic Learning Process

By examining the progress in strategic thrust and checking accomplishment of the results, managers can look for the successful implementation or for deviations from the plan. In this way the lessons about strategy execution could be learned – successful methods should be adopted and perpetuated. In the case of deviations – corrective actions should be taken in order to reaching planned objectives component – compare figure 1, stage Act/Adjust. Such procedure could be explained as single-loop learning according to the concept of Argyris and Schön (1978). In this type of learning the theory, which steers of actions done – namely the strategy – remain stable in the sense that the objectives and targets are constant. Any departure from the planned course of actions is interpreted as a failure to be remedied (figure 2, arrow from 'Act/Adjust' to 'Do'). Such single-loop learning process does not require validating and rethinking of strategy (Kaplan and Norton 1996; Steinmann and Schreyögg 2000). In this case, strategy (plan) remains exogenous category from the learning process point of view, what is stressed by the dark colour of the arrow on the figure 2.

Contemporary organizations have to become capable of double-loop learning (Kaplan and Norton 1996). In this type of learning the

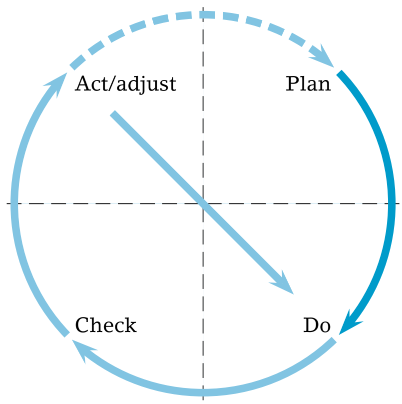

FIGURE 2
The Single- and Double-Loop Strategic Learning Framed on the PDCA Cycle

theory (strategy) do not remain constant any more. Premise control and strategic surveillance discussed above could be seen as a basis of such strategic double-loop learning which facilitate critical assessment of the strategy (Kaplan and Norton 1996; Steinmann and Schreyögg 2000). According to the results of testing validity of strategy (verifying strategic assumptions and monitoring changes) strategic plan is confirmed, adapted and rethought component – compare figure 1, stage Act/Adjust. In this case, strategy (plan) became endogenous category from the learning process point of view, and starts to be driven by Act/Adjust stage, what is stressed by the arrow, which illustrated this relation (figure 2, dashed line). To sum up, single-loop learning process is based on DCA cycle: implementation of the strategy (Do) – monitoring progress of initiatives and accomplishment of targets (Check) – fixing or correcting methods (Act/Adjust). However, in the complex world suffered from uncertainty it would not be enough. In such world, strategy could not be treated any more as being graven on tablets of stone. Validity of strategy must be permanently tested and according to this strategic plan should be confirmed, rethought or adapted. As the result – contemporary strategic management must be treated as a continuous learning process based on both single and double-loop method framed on the PDCA cycle (figure 2).

Conclusions

In the complex and uncertain environment traditional approach based on one-shot best strategy, planning could not be longer valid. Strategic planning and management have to be permanent and dynamic process as such it must be a form of collective organizational learning. Organizational learning helps organizations to enhance their practices and to prosper in a dynamic and competitive environment. According to Agryris and Schön's (1978) model such learning process, have to be based on double loop learning. The useful framework for strategic organizational learning could be PDCA cycle, which allows following both single and double loop learning.

Authors are convinced that further research in the area of organizational learning and strategic management is needed to better understand the relationship between those fields of interest. Interesting framework of such research seems to be the plan-do-check cycle, which is useful form of Bacon's reasoning: hypothesis-experiment-evaluation. Following the PDCA cycle allows conducting both form of strategic learning: single-loop and double-loop learning. The procedure of single-loop learning is quite well developed in theory and intuitively used by practitioners of strategic management. However, the double-loop strategic learning seems to remain the challenge both for scientists and for practitioners. Future studies could look at this problem, particularly at methods of facilitating strategic organizational learning, and the impact of it on strategic outcomes. The Balanced Scorecard methodology and particularly strategic maps seems to be very promising area of research. In addition, studies of the strategic learning process in the public sector seem to be very interesting.

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Risk Consideration and Cost Estimation in Construction Projects Using Monte Carlo Simulation

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Construction projects usually involve high investments. It is, therefore, a risky adventure for companies as actual costs of construction projects nearly always exceed the planed scenario. This is due to the various risks and the large uncertainty existing within this industry. Determination and quantification of risks and their impact on project costs within the construction industry is described to be one of the most difficult areas. This paper analyses how the cost of construction projects can be estimated using Monte Carlo Simulation. It investigates if the different cost elements in a construction project follow a specific probability distribution. The research examines the effect of correlation between different project costs on the result of the Monte Carlo Simulation. The paper finds out that Monte Carlo Simulation can be a helpful tool for risk managers and can be used for cost estimation of construction projects. The research has shown that cost distributions are positively skewed and cost elements seem to have some interdependent relationships.

Key words: risk management, Monte Carlo Simulation, construction, probability distribution

Introduction

Many construction projects are undertaken in a complex and continuous changing environment. Systems and approaches are developed by theoreticians and used by practitioners to cope with the new challenges. While for some industries these systems have a sufficient number of mathematical models for risk analyses, the construction industry suffers from underdevelopment (Flanagan and Norman 1993). This is partially due to the non-homogeneous and non-serial character and the high dependence of the success of the projects linked to the skills of the individual project manager. Furthermore, the increased national and international competition forces the constructors to focus on their core competence. These effects result in an increasing degree of outsourcing and a reallocation of the risks related to costs, time schedule and quality (Girmscheid and Busch 2014).

According to a survey of the Philipp Holzmann AG, 41% of the losses of construction projects is related to miscalculations in the pre-contract phase and 22% to project risks. 30% of the costs incurs during the construction phase and only 7% is related to force majeure. Philipp Holzmann AG could have increased the margin by 3% in avoiding 10% of the poorest contracts (Linden 1999).

Smith (1999) finds out that expenditure on the appraisal of major engineering projects represent only 10% of the capital costs of the project. However, during this period 80% of the total project costs are frozen. This shows how important the identification of the major risks and estimation of the costs at the beginning of a construction project are.

In 2008, the Boston Globe pointed out that the project 'Boston's Big Dig' ended up costing almost $22 Billion vs. a budget of $2.6 Billion (Murphy 2008). The German Airport Berlin-Brandenburg showed in June 2014 a cost overrun of more than 150% to an amount of 5.4 Billion € (see http://www.flughafen-berlin-kosten.de/). These are only two examples of a huge number of miscalculated projects with cost overruns showing that an adequate cost calculation is more than needed. Such a cost calculation has to consider beside the basic costs also contingencies, which represent the risk of the project. For this, a well-implemented and complete risk management system with mathematical models for the risk analysis is needed. This is not easy, as the practitioners of the construction industry believe that the success of the project is highly dependent on the experience of the project manager gained over many years. They believe that experience cannot be easily transferred to mathematical models (Ashworth 1987).

Within risk management process the risk analysis is seen as the most difficult component, but it is also the most useful (Touran, Yang, and Lowe 2011). This paper is focused on finding out if the Monte Carlo Simulation can be used to improve risk analysis and hence lead to a better estimation of costs in construction projects.

Literature Review

Every venture bears a risk. Therefore, it is important to understand how a risk is defined and what its sources are. In general, a risk can be defined as any uncertainties that, if it occurs, would affect one or more objectives (Hilson 2004). Hence, risk bears threat and opportunities. Usually six types of risks can be defined for the construction area (Girmscheid and Busch 2014):

- legal risks
- scheduling risks
- technical risks
- financial risks
- management risks
- environmental risks

However, a common use and interpretation of the risk types does not exist in the literature. Not all six types of risks may be important for a specific construction project. The dimension of the risks will be defined by factors as project size, environment, skills and experience of the employees, financial factors, technical complexity of the project, etc. Beside the basic costs of a project, which mainly consist of design, production (cost for labour and construction material) and installation, the total costs of a construction project and hence the success of the project is affected by risks.

An overview of the published work on the topic risk and the valuation of construction projects were performed by Touran, Yang and Lowe (2011). The considered literature mainly describes risk models based on the estimation on probabilities and their effect. They remark that a sufficient database is not given for the used stochastic models to analyze the cost and time table risks. Detailed remarks of mathematical evidence according to this statement are not given.

In a study performed 1992 Touran and Wiser (1992) used information from 1.014 low-rise buildings in the US The costs were broken down to 15 different items. After a Test of Goodness of Fit on each cost item, the lognormal distribution was concluded to fit best. The results were used to perform the Monte Carlo Simulation, once with assuming independence of the data and then with recognizing correlations.

A literature review of Baccarini (2005) came to the result that traditional percentage is the most commonly used estimating method in practice for considering project cost contingencies. However, other methods gained more and more interest, of which one is the Monte Carlo Simulation.

Wall (1997) analyzed a number of 216 new built offices from the UK. After the Test of Goodness of Fit was performed, the beta and lognormal distributions were used for the Monte Carlo Simulation. Furthermore, the author concluded that correlations between the cost items have to be taken into account. Ignoring the correlation is more intense than the choice of the distribution, lognormal or beta. Previous studies agree that by considering correlation in simulating and analyzing the risk results in a better estimation of variance of the distribution of total costs of construction projects (Chou 2011; Yang 2005; Flanagan and Norman 1993).

Hollauf (n.d.) reviewed construction projects in the UK. Data for a sample size of 58 construction objects were analyzed. The author found out that a dependency between the different cost elements exists and the correlation between these needs to be taken into account when performing Monte Carlo Simulation.

The German authors Girmscheid and Busch (2007) recommend the Monte Carlo Simulation among others for quantifying risk. In using the Monte Carlo Simulation, the authors agree that experts have to define for each risk a minimum, maximum and most reliable outcome and the corresponding probability. The resulting risk has to be considered as contingency in the general costs of the project.

Some authors define the venture during the construction period as uncertainties and not as risk. This is because the venture is based on subjective estimation and not on statistical investigation. The use of probabilities based on subjective assumptions lead to misinterpretations. Loizou and French (2012) make some critical notices to the use of the Monte Carlo Simulation in the construction industry as for every event subjective probabilities have to be designed. Statistical data from the past is often not available or statistical not significant.

Summarizing the literature, it can be said that for construction projects the analysis of risk and its potential impact is proposed. However, the conditions to determine the input parameters are rarely discussed. The critic of the literature focuses on subjective assumptions for probabilities, which can lead to misinterpretations. An analysis of historical data and their use in the context does exist only rudimental.

Methodology

During the proposal stage, a feasibility study is usually initiated without knowing the exact design and demands of the client. Due to the high risk within this business and to prevent cost overruns, it is common to add a reserve amount to the project costs, the so-called contingency. The calculation methods for such contingencies can be divided into three main categories: deterministic methods, probabilistic methods and modern mathematical methods (Bakhshi and Touran 2014).

Current practice considers risks of the project such as changes in design and project by applying a contingency allowance based on deterministic methods or single point estimation. These methods are easy to handle without demanding a high knowledge of statistics, but as the conditions are not stable, the utility of this approach is reduced. It is highly recommended to use a range estimation rather than single point estimation. This way the variation in the outcomes is reflected (Elkjaer 2000). The two methods that can be used to analyze risk in the estimation of project-outrun costs are sensitivity analysis and probabilistic risk analysis (Tan and Makwasha 2010).

These approaches require a big range of data. However, historical data are limited especially in the construction industry. The problem could be solved by using simulations like Monte Carlo Simulation. Simulation based cost analysis requires two sets of data inputs which are, the marginal distribution of the individual cost elements and the correlation matrix consisting of the correlation coefficients between the different pairs of cost elements. Both sets of inputs can be estimated in two ways, (1) using historical data from past projects, (2) subjective judgment or using experience and intuition (Yang 2005).

This research tries to find out how Monte Carlo Simulation can be useful to estimate the costs and determine the contingency for the project, based on historical data. The approach follows the next five steps:

- Collection of historical data
- Definition of the Total Construction Costs (TCC)
- Test of Goodness of Fit
- Determination of correlation
- Monte Carlo Simulation

The used historical data are in accordance with the cost breakdown structure as applied by the BKI (Baukosteninformationszentrum Deutscher Architektenkammern). The data used in this research was obtained from the Kostenplaner 17 CD. The cost structure follows the DIN 276-1:2008-12. The costs of a building are class-divided into costs for the land, on-site infrastructure works, building construction, external areas, equipment and artwork and incidental costs. This research focuses on the building costs consisting of costs for the building pit, foundation, exterior walls, interior walls, ceiling, roof, fittings and other measures for construction.

Cost data of totally 75 administrative buildings in Germany are analyzed. The buildings were finished between 1976 and 2013. The gross floor area of the buildings is between 269 and 25.134 square meter. 24% of the buildings have a gross floor area of less than 1.000 m^2 and 33% higher than 5.000 m^2Ẇhile 84% of the buildings is from the private sector, the rest is from public sector.

The sample was assumed large enough to minimize the sampling error that could occur in such studies and is considered a good representation of the population. The sample group, was chosen as it had more data available than other groups. By presenting the data in cost per square meter, the problem of project size or scale is eliminated.

The TCC are defined to be the sum of the elemental costs per square meter. The gross floor space of the buildings is used as the common factor for the different cost elements. This step is followed by the definition of the probability distributions for the cost elements. This will be done by performing the Anderson-Darling Test.

The determination of the correlation between the cost elements is very important. If correlations are ignored, this might result in a significant underestimation of the costs for the job. For the correlation matrix, the Spearman rank correlation coefficients will be calculated. The correlation matrix will then be tested for its feasibility as appropriate (Yang 2005).

Using the results, Monte Carlo Simulation will be performed with the help of the Software Crystal Ball®. Each simulation generates a random set of possible values for each of the cost elements according to the specified marginal distributions. Two sets of 100 000 runs will be performed; one incorporating correlated data and the other assuming independence of elemental cost data.

Monte Carlo Simulation

This paper researches in which way historical data of construction projects follow a certain distribution and if these data can be used to model the possible future costs of a project.

TABLE 1 Descriptive Statistics for Elemental Cost Data

Item	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mean	29.68	259.14	472.00	258.94	296.60	330.99	26.20	45.76
Median	20.15	256.10	467.57	227.91	281.76	292.48	14.86	39.03
Variance	842.78	10214.52	27433.61	20277.98	7786.95	14984.88	1009.33	811.85
Std. var.	29.03	101.07	165.63	142.40	88.24	122.41	31.77	28.49
Min	5.59	11.02	170.42	100.52	157.11	148.29	0.17	10.28
Max	148.73	686.67	1.040.81	1.249.99	616.62	674.71	145.38	156.30
Range	143.14	675.65	870.39	1.149.47	459.51	526.42	145.21	146.02
1st quart.	13.08	194.75	326.17	185.15	239.38	247.41	3.38	25.33
3rd quart.	29.72	319.13	598.71	300.61	353.39	406.48	32.02	60.71
Skew	2.44	1.15	0.60	4.78	1.10	0.84	1.99	1.41
Kurtosis	6.26	3.84	0.53	31.66	2.38	0.11	4.01	2.60
Mean std. err.	3.47	11.67	19.13	16.44	10.40	14.14	4.28	3.29

NOTES Column headings are as follows: (1) building pit, (2) foundation, (3) exterior walls, (4) interior walls, (5) ceiling, (6) roof, (7) fittings, (8) others.

TEST OF GOODNESS OF FIT

The fitting of the distribution to each cost element was done by using the Software Crystal Ball®. The Anderson-Darling test was used to decide on the best fit for each element. The Anderson-Darling Test measures the distance between the hypothesized distribution F and the empirical cumulative distribution function F_n (Anderson and Darling 1952).

$$A = \int_{-\infty}^{\infty} \frac{(F_n(x) - F(x))^2}{F(x)(1 - F(x))} dF(x). \tag{1}$$

Table 1 gives an overview of the statistics of the data. For all cost components, the best fitting distribution is the lognormal. It can be noted that the marginal distributions of the cost elements are all positive skewed and all the cost components have a mean, which is greater than the median. This is consistent with past researches (Wall 1997). The exterior walls have the highest costs per square meter with the highest variance. The positive skewness of the distributions does not really surprise, as construction projects rather tend to have costs overruns then lower costs as foreseen.

The tails of the distribution of the cost elements are longer to the right side, which suggests that a major part of the costs fall below the average, but a few extreme cases exceed the average. These extreme cases are subject to risk management and need to be taken into consideration. They can lead to project overruns. The tail probabilities have to be studied to set up the contingency for a project.

TABLE 2 Anderson-Darling Goodness of Fit Test

Item	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Distribution	L	L	W	L	L	L	L	L
A–D	0.46	0.35	0.46	0.41	0.32	0.28	0.57	0.19

NOTES Column headings are as follows: (1) building pit, (2) foundation, (3) exterior walls, (4) interior walls, (5) ceiling, (6) roof, (7) fittings, (8) others. L – lognormal, W – weibull, $\alpha = 95\%$.

Half of the distributions have a kurtosis value higher than three. This indicates them being more peaked or having taller peaks compared to the normal distribution. This indicates the portion of extreme deviations from the mean value being high. This is mainly for the interior walls, while exterior walls are highly platykurtic with a value of 0.53.

It is crucial to specify the probability distribution of the cost elements. The quality of the results for the better-fit test increases with the available number of data. Previous studies assume the beta, uniform, triangular and lognormal distributions to fit best to the cost data. For historical data, researches suggest the lognormal distribution to fit the best (Touran and Wiser 1992; Wall 1997) This research is in line with past results and finds out that for almost all the given data the lognormal distribution is the best fitting.

Table 2 gives an overview of the results. For the exterior walls, the Weibull distribution fits the best. Nevertheless, the lognormal distribution for the exterior walls has also a good A–D value with 0.5789.

CORRELATIONS OF THE COST ELEMENTS

When running a simulation-based cost analysis correlations must be considered if they are significant (Yang 2005). Ignoring correlations might result in a significant underestimation of the costs for the job, and this becomes even more significant if we consider a portfolio of different jobs (Bakhshi and Touran 2012). The rank (Spearman) correlation coefficient was used to reflect the degree of relation between the different cost elements. The advantage of the Spearman correlation coefficient is its use in case of a non-linear relationship between the variables and if both populations are not normally distributed (Yang 2005). The Spearman correlation coefficient is defined by following equation:

$$r_{xy} = 1 - \frac{6\sum_{i=1}^{n} d_1^2}{n(n^2-1)}, \qquad (2)$$

TABLE 3 Spearman Rank Correlation Coefficient

Item	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	1.0000	0.2108	0.1422	0.0898	0.1742	0.2081	0.1371	0.1258
(2)		1.0000	0.2773	0.2462	0.2858	0.2484	0.0149	0.3382
(3)			1.0000	0.5709	0.4924	0.5621	0.1746	0.4293
(4)				1.0000	0.4538	0.5175	0.2952	0.3217
(5)					1.0000	0.5775	0.4238	0.2991
(6)						1.0000	0.1489	0.3654
(7)							1.0000	−0.0604
(8)								1.0000

NOTES Column headings are as follows: (1) building pit, (2) foundation, (3) exterior walls, (4) interior walls, (5) ceiling, (6) roof, (7) fittings, (8) others.

where d is the difference between the ranks of the corresponding x and y. The coefficients can range between −1 and +1. A coefficient of +1 shows a perfect positive and −1 a perfect negative relationship. Analysis of the data shows a positive correlation between the different cost elements. This is also in line with past research (Wall 1997).

To find out the significance of the correlation, a null hypothesis was tested against an alternative hypothesis. To test the spearman rank order correlation coefficients for significance at a level of 5%, the Z score test was performed.

- Null hypothesis: $C_{ij} = 0$
- Research hypothesis: $C_{ij} \neq 0$

$$z_{ij} = C_{ij}\sqrt{N-1}, \tag{3}$$

where C is the correlation between the different cost elements and N is the sample size.

The statistics transform the correlation coefficients to z scores on the standard normal probability distribution. The test statistic z is normally distributed for $N > 30$ and therefore can be compared to the critical values z of the standard normal distribution. To test if the correlation coefficient is significantly different from zero the above test statistics are compared to the 1.96 critical value of z at the 5% level of significance. Table 4 reflects the outcome.

The Z score test shows a significant correlation between some of the cost elements. This is consistent with past research (Yang 2005). The correlation is significant mainly between the costs for the main structures of a house: ceiling, walls and the roof. For 17out of 28 of the coefficients, the critical value of 1.96 is exceeded. The use of a

TABLE 4 *Z* Score for the Correlations of the Cost Elements

Item	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	1.0000	1.7514	1.1808	0.7463	1.4470	1.7288	1.1385	1.0450
(2)		1.0000	2.3852	2.1177	2.4586	2.1369	0.1279	2.9094
(3)			1.0000	4.9113	4.2359	4.8355	1.5024	3.6929
(4)				1.0000	3.9039	4.4520	2.5395	2.7676
(5)					1.0000	4.8659	3.5707	2.5200
(6)						1.0000	1.2805	3.1429
(7)							1.0000	−0.4438
(8)								1.0000

NOTES Column headings are as follows: (1) building pit, (2) foundation, (3) exterior walls, (4) interior walls, (5) ceiling, (6) roof, (7) fittings, (8) others.

correlation matrix in the Monte Carlo Simulation has to be feasible. This restricts the matrix to be positively semi definite, which means that the eigenvalue of the matrix must be non-negative (Yang 2005). A further discussion is not required as in the given situation the used correlations are all positive.

SIMULATION OF THE TOTAL COSTS OF CONSTRUCTION

For modelling, the distribution of the TCC the Monte Carlo Simulation was applied by using Crystal Ball®. Monte Carlo Simulation generates samples $\{X^{(r)}\}_{r=1}^{R}$ from a given probability distribution $P(x)$. For each cost element, the best fitting probability distribution for its historical data was used. The details of the distribution are described in the above tables one and two. If we talk about simulation, we talk about generating a sample of random numbers. These numbers can be out of a range between 0 and 1. Monte Carlo is used to solve a mathematical or statistical problem. For example, when we throw darts on a figure and determine the relation of the hits to the missed darts. A Monte Carlo Simulation uses the random sampling of an experiment to determine the properties of some phenomenon (Sawilowsky 2003).

It was found out that the distributions of the TCC are positively screwed and show a heavy tail to the right. This is not surprising and again in line with past research results (Yang 2005). Furthermore, it was shown that the distribution without correlation of the cost elements has a lower range of possible outcomes. This means that the TCC without correlation underestimates the cost risk of a project. It points out that correlation needs to be accounted for when costs are estimated. The potential of running low costs, but also running losses is bigger because correlated construction factors add up each

TABLE 5 Statistics for the Two TCC Distributions

Statistics	TCC without correlation	TCC with correlation
Trials	100000	100000
Mean	962.61	962.67
Median	946.42	927.71
Mode	—	—
Standard deviation	178.58	280.07
Variance	31.891.93	78.441.83
Skewness	1.51	1.45
Kurtosis	17.17	13.46
Coefficient of variability	0.19	0.29
Minimum	456.70	322.96
Maximum	5.154.76	7.789.76
Range width	4.698.06	7.466.80
Mean standard error	0.56	0.89

other. Further, it has to be mentioned that the distribution of the TCC without correlation has a greater peak, while both distributions are highly leptokurtic.

The results of the Monte Carlo Simulation can be used to get a better understanding of the range of the costs. Constructors can make visible which effect risks could have on the costs of a project and how the effect can increase or decrease because of correlation between the cost elements. Furthermore it is possible to define which the minimum costs of the project are if a certain probability is demanded. For example the project costs will not exceed 1.400 €/m^2 with a probability of 90%. The results are shown in table 3.

Conclusion

The research investigated how Monte Carlo Simulation can be used for cost estimation in construction projects. While the major part of past studies conclude that the estimation of the distribution for the cost elements has to be done subjective by experts, this paper analyses if historical data can be used for Monte Carlo Simulation. Furthermore, it analyses if a significant correlation between the input factors of the Monte Carlo Simulation exists.

It was found out that historical data could be used for a Monte Carlo Simulation to give project manager an idea of the variation in costs. It can be implemented into the risk management process to take better decision on the best mitigation strategy. The average cost of the selected office buildings used is about 962€/m^2 per square meter, while ignoring quality, technology, location and other factors.

It was shown that the average value could be exceeded by a very large amount.

More than half of the correlations between the cost elements were significant at a coefficient level of 95%. The resulting two probability distributions show that the consideration of the interdependency is important in the risk analysis and must be incorporated in the estimation of the total costs. Ignorance of the correlation might lead to an underestimation of the variance of the project costs. This can lead to inadequate contingencies set up.

It was shown that the lognormal has the best fit compared to other distributions on most of the cost elements. The TCC distribution is likely to be lognormal itself due to self-replication property of the lognormal distribution. The TCC distribution is heavily reliant on the marginal distributions of the cost elements, which are dependent on the data, used.

The research did not consider the price variance of the buildings resulting from the type of the buildings, quality or location. This might have contributed to the large variation and outliers in the data. A further refinement might result in a higher accuracy of the estimation but this will result in less historical data.

As mentioned at the beginning of this paper, in particular for the construction industry the selection of the projects is high sensitive. Companies within this business are characterized by a small number of high volume projects. The projects have a realization time of some months or even years. These facts imply a high volume of investments for a longer period. The investments are related not only to the construction materials, but also to production facilities, etc. As a result, the economic success and future of a company is high dependent on the success of singular projects. How important the right choice of projects are, shows the example of the Philipp Holzmann AG. Philipp Holzmann AG could have increased the margin by 3% in avoiding 10% of the poorest contracts (Linden 1999).

Companies need to include their experience gained from past projects accurate into their project calculation for new tenders. This way it is easier to offer a price to the client that covers the costs/risks and ensures the company's future. Finding the right tender price is decisive in competitiveness. A low price would not necessarily cover all risks and a high price would result in losing a tender to a better-prepared competitor. The current practice considers the risks of the project mainly by using single point estimation. These methods are easy to handle but the utility is limited (Elkjaer 2000). The use of the Monte Carlo Simulation by using past data as shown in this paper reflects the variation in the outcomes. Project manager get a visible range of the possible outcomes of the projects, which ensures a better decision.

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The Framework of Quality Measurement

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The paper describes general determinants of quality measurement. There are discussed four assumptions that have been formulated to develop the framework of quality measurement. The assumptions are: (1) quality is the degree to which a set of inherent characteristics fulfils requirements, (2) requirements and inherent characteristics create finite sets, (3) requirements may have both different importance and different values depending on who formulates them, and (4) requirements do not have to be constant in time. The article contains the framework of quality measurement based on above four assumptions. There are proposed notation on the quality measurement on booth synthetic and the analytical level. It also contains examples of selected distance metrics in m-dimensional space as well as examples of selected aggregate functions that may be used in quality measurement on synthetic level.

Key words: quality measurement, quality management, TQM

> I often say that when you can measure what you are speaking about and express it in numbers you know something about it; but when you cannot express it in numbers your knowledge is a meagre and unsatisfactory kind – it may be the beginning of knowledge but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be.
>
> *Lord Kelvin*

Introduction

Much has been written about the importance of quality in any aspect of management and economy (Oakland 2014; Flynn, Schroeder, and Sakakibara 1995; Deming 1982; Juran and De Feo 2010; Juran 1999; Harrington 1991; Sousa and Voss 2002). There is no need to repeat generally known rules about significance of quality, but there is still a challenge how to measure the quality. As James Harrington had said: 'If you can't measure something, you can't understand it. If you can't understand it, you can't control it. If you can't control it, you can't improve it' (Spitzer 2007, 19). Quality measurement methods are still being developed. There are specific methods for measuring the quality of a particular industry (Abbott 1999; Winkler and Mohandas 2008; Mor et al. 2003; Garvin et al. 2012; Alabaster and Lloyd 2013; Zoogman et al. 2011) but there is a need to develop a framework of quality measurement, which will set the standard of quality measurement.

To build the framework of quality measurement, it is essential to adopt certain assumptions about the essence of quality. Fundamental is the definition of quality.

The Assumptions About the Essence of Quality

The quality definition constitutes a basic assumption. There are many approaches to defining quality; most of authors quote categories of quality definition described by D. Garvin: the transcendent approach of philosophy, the product-based approach of economics, the user-based approach of economics, marketing, and operations management, and the manufacturing-based, value-based approaches of operations management (Garvin 1984; Sebastianelli and Tamimi 2002; Baker and Crompton 2000). Author of this article has adopted the definition of quality provided in clause 3.1.1 of the ISO 9000:2005, where the quality is defined as 'the degree to which a set of inherent characteristics fulfils requirements.' The authors of ISO 9000:2005 suggest the possibility of applying the notion of 'quality' with such adjectives as poor, good, excellent. According to the above-mentioned standard, 'inherent,' as opposed to 'assigned,' means existing in something, especially as a permanent characteristic. According to clause 3.1.2 of ISO 9000:2005, requirement is a 'need or expectation that is stated, generally implied or obligatory.' 'Generally implied' means that it is a custom or common practice for the organization, its customers and other interested parties, that the need or expectation under consideration is implied (note 1 to clause 3.1.2 of ISO 9000:2005).

The definition presented in the ISO standard is the most universal and, due to precise limitation of the notion of quality only to inherent characteristics and requirements, quality is clearly a measurable category. Use of the definition from the ISO standard enables also application of the framework of quality measurement in enterprises having a quality management system compliant with the ISO 9001 standard. Particularly, the proposed framework may be helpful in the fulfilment of the requirements described in items 7.3 (design and development) and 8.2.4 (product monitoring and measurement) of the EN ISO 9001 standard.

It has been assumed that *both formulated requirements and inherent characteristics may be of any number, but finite in both cases.* This does not mean that these sets must be equinumerous. A situation in which a series of inherent characteristics is responsible for fulfilment of the same requirement regarding the object cannot be excluded.

The Pareto principle, which states that 80% of the effects come from 20% of the causes, may be useful in the identification of both requirements and inherent characteristics. Translation of the Pareto principle directly into the quality measurement would mean that 20% inherent characteristics would affect the fulfilment of 80% of the requirements.

Another assumption allows the quality subjectivism; it means that *requirements may differ depending on who formulates them.* Particular requirements may differ with both their importance and desired target values. In particular, the most important thing for one type of stakeholder may be less important or generally unimportant for another stakeholder. Similarly, values of inherent characteristics can be completely different depending on who formulates the requirements. On the market are custom-delivered products and products addressed to a large amount of customers. The results of segmentation and analysis of values of particular segments determine whose requirements should be considered in a product.

More over *requirements do not have to be constant in time.* Usually, we observe the variability of requirements concerning their value, importance and number in time. Together with development of civilisation, standards expected from products and services may vary. Clear dynamics of changes in requirements may be observed on the market of modern technologies. For example, requirements regarding personal computer parameters from ten years ago or longer differ from the present-day standards. In addition, requirements concerning portable music players were different 20 years ago, and today the newer ones are valid. Many examples of changes in requirements in time may be provided. However, it is not a misapprehension that the discussed assumption has been formulated as a contradiction of the necessity of constancy of requirements in time, as it is possible to find such products and market segments where constancy of requirements is appreciated. For example, gastronomic services based on traditional meals are better assessed the closer they are to requirements posed many years, or even centuries, ago. On this market, quite a few producers boast of a recipe that has not changed for centuries.

Conceptualization of the Framework of Quality Measurement

In highly competitive market the quality management in organizations become critical, as well as the need of quality measurement. There were many attempts to develop quality measurement method. Most famous are Six Sigma, Servqual, and Servperf. There are also many conceptual models, for example: technical and functional quality model (Grönroos 1984), GAP model (Parasuraman, Zeithaml, and Berry 1985), attribute service quality model (Haywood-Farmer 1988), synthesised model of service quality (Brogowicz, Delene, and Lyth 1990), performance only model (Cronin and Taylor 1992), ideal value model of service quality (Mattsson 1992), evaluated performance and normed quality model (Teas 1993), evaluated performance (EP) framework (Teas 1993), normed quality model (Mattsson 1992), IT alignment model (Berkley and Gupta 1994), attribute and overall affect model (Dabholkar 1996), PCP attribute model (Philip and Hazlett 1997), retail service quality and perceived value model (Sweeney, Soutar, and Johnson 1997), service quality, customer value and customer satisfaction model (Oh 1999), antecedents and mediator model (Dabholkar et al. 2000), internal service quality model (Frost and Kumar 2000), internal service quality DEA model (Soteriou and Stavrinides 2000), framework for measuring service quality (Sureshchandar, Rajendran, and Kamalanabhan 2001), model of e-service quality (Santos 2003). Most of mentioned models are well described by Seth, Deshmukh, and Vrat (2005). There are opinions about Six Sigma that 'its focus on processes and variation is central to what is historically thought of as "quality control" and can be found in works by W. Edwards Deming and Walter A. Shewhart.' (Klefsjö, Wiklund, and Edgeman 2001). B. Morris had written, 'one of the chief problems of Six Sigma, say Holland and other critics, is that it is narrowly designed to fix an existing process, allowing little room for new ideas or an entirely different approach. All that talent – all those best and brightest – were devoted to, say, driving defects down to 3.4 per million and not on coming up with new products or disruptive technologies (Morris 2006).

In my opinion, all above mentioned methods and models are very specific and their authors omit the generic assumptions on the essence of quality. They especially omits assumption 3 (requirements may have both different importance and different values depending on who formulates them) and 4 (requirements do not have to be constant in time). On the operational level, authors of mentioned methods seem to ignore the phenomenon of limited substitution between inherent characteristic.

Quality measurement may be conducted on two levels: analytical and synthetic. On the analytical level, an *n*-dimensional vector of values of inherent characteristics describing the object's qualitative condition constitutes a measurement result. On the synthetic level, a measurement result is constituted by a dimensionless scale within the range $< 0, 1 >$, where 1 means full compliance of inherent characteristics with the requirements, while 0 means a complete lack of compliance, all other values represent partial compliance with the requirements, the higher degree to which a set of inherent characteristics fulfils requirements the closer the result of measurement is to 1. To interpret a measurement result on the analytical level, additional knowledge about identified requirements and inherent characteristics (particularly their importance and accepted ranges of variability) is necessary. Moreover, it is assumed that a recipient of measurement results knows the character of particular inherent characteristics (stimulant – the larger the better, destimulant – the smaller the better, nominee – nominal the best) and their impact on a degree of fulfilment of requirements. A requirement for additional knowledge means that the quality measurement results from an analytical level is addressed to individuals having expert competencies within the scope of a sector from which the tested object comes. On the synthetic level, a measurement result is much simpler for interpretation and more useful to compare the quality of objects by those who do not have expert knowledge within the scope of inherent characteristics of the object and identified requirements. On the synthetic level, measurement enables quality optimisation within a much larger scope than a measurement on the analytical level.

Having regard to adopted assumptions, each quality measurement is designated by the time of its occurrence and a subject formulating requirements. An individual unit (e.g. human being, organisation) or a group of units may constitute this subject. Both on the analytical and synthetic level, identification of requirements are done in order to determine the quality pattern of a desired object. *Quality pattern* contains list of inherent characteristics with a desired target value, importance and type (stimulant, destimulant, nominants). Depending on the size of the research population and the budget allocated to establish the requirements might be applied:

- study of all individuals,
- random sampling,

- stratified sampling,
- study of individuals regarded as pattern for appointed segments,
- determine the quality pattern by experts.

In the event of a group of units where full compliance of requirements does not occur, it is important to conduct a segmentation process where segments of similar requirements regarding an object shall be appointed. Such a division of subject where differences within a segment are minimised and differences between various segments are maximised constitutes the main principle of segmentation. Among the advantages of segmentation, McDonald and Dunbar (2010, 40) mention:

- recognising customer' differences is the key to successful marketing, as it can lead to a closer matching of customers' needs with the company's products or services;
- segmentation can lead to niche marketing, where appropriate, where the company can meet the needs of customers in that niche segment resulting in segment domination, something which is often not possible in the total market;
- segmentation can lead to the concentration of resources in markets where competitive advantage is greatest and returns are high;
- segmentation can be used to gain competitive advantage by enabling you to consider the market in different ways from your competitors;
- by means of segmentation, you can market your company as a specialist in your chosen segments, with a better understanding of the customers' needs, thus giving your products or services advantages over those of your competitors.

Development of a quality pattern includes three stages:

- Identification of requirements.
- Segmentation of requirements.
- Conversion the requirements of selected segments into values of inherent characteristics and determination of accepted ranges of variability for each characteristic.

In this paper, specific designations shall be adopted for the needs of framework of quality measurement. Ω shall designate a set of n vectors δ^n, where δ^n constitutes p-dimensional vectors of the following components $(\delta_1;\gamma_1), (\delta_2;\gamma_2), (\delta_3;\gamma_3), \ldots, (\delta_p;\gamma_p)$. Parameter p itself may have values from 1 to k, where k is the maximum number of identified requirements in relation to an object, which quality is measured. δ_i for $i = 1 \ldots p$ means the i-th requirement formulated by a unit in relation to the object, γ_i means importance of the i-th requirement on the interval scale $0 \ldots m$. For example, a very simplified set Ω of the number 2 for a passenger car might look as follows:

- δ^1 =< (δ_1 = fuel consumption (E95 petrol) below five litres per 100 km, $\gamma_1 = 7$ on the 10-point scale), (δ_2 = safety assurance in the event of head-on collision, $\gamma_2 = 10$ on the 10-point scale), (δ_3 = green car frame, $\gamma_3 = 3$ on the 10-point scale) >,
- δ^2 =< (δ_1 = fuel consumption (E95 petrol) below six litres per 100 km, $\gamma_1 = 6$ on the 10-point scale), (δ_2 = safety assurance in the event of head-on collision, $\gamma_2 = 10$ on the 10-point scale), (δ_3 = green car frame, $\gamma_3 = 0$ on the 10-point scale)>.

After completion of the segmentation process, the next stage is constituted by the exchange of a set of homogenous requirements (Ω_S segment), being Ω subset, into k-dimensional vector $\vec{X}$ of model values of the object's inherent characteristics. $\vec{X}$ vector includes k following components ($x_k; x_{k\_min}; x_{k\_max}; \beta_k$), where x_k is an optimal value of the k-th value, x_{k_min} is a minimal acceptable value of the k-th value, x_{k_max} is a maximal acceptable value of the k-th value, and β_k – is a coefficient defining importance of the k-th value on the interval scale $1 \ldots r$.

Customers' requirements do not have to be synonymous with values of inherent characteristics. Often, a subject formulating requirements does not acquire appropriate knowledge about the technology of the object performance and cannot define model values of inherent characteristics on its own. The part of the QFD method which concerns obtaining target values for technical parameters (field VIII in the QFD 'House of Quality'), may be used to exchange requirements into values of inherent characteristics. In addition, a result obtained through the QFD method should be completed with acceptable ranges of variability for each characteristic. Subsequent specification of requirements and inherent characteristics responsible for their fulfilment creates a precise documentation of the quality model expressed in units of inherent characteristics.

As regards the measuring abstractions Early and Coletti (2010, 123) claim that 'Some quality features seem to stand apart from the world of physical things. Quality of service often includes courtesy as a significant quality feature. Even in the case of physical goods, we have quality features, such as beauty, taste, aroma, feel, or sound. The challenge is to establish units of measure for such abstractions.'

TABLE 1 Scale of relative states

Classes of quality states	Class discriminant	State
0	0.95	Superb
1	0.85	Distinguished
2	0.75	Profitable*
3	0.65	Convenient*
4	0.55	Moderate
5	0.45	Intermediate
6	0.35	Inconvenient
7	0.25	Unfavourable
8	0.15	Critical
9	0.05	Bad

NOTES * Normal. Adapted from Kolman (2009, 38) and Dudek-Burlikowska and Szewieczek (2008).

In order to measure quality on the analytical level, it is necessary to define which inherent characteristics should be measured, in what units and with what accuracy. The framework of the object's quality measurement on the analytical level may be written in accordance with the formula:

$$Q(O, W_{in}, t) = < I_1, I_2 \ldots I_n >, \tag{1}$$

where O is the object of the quality measurement, t is the time of conducting the quality measurement, W_{in} is the type and number of inherent characteristics describing identified requirements together with units and accuracy of measurement, and $I_1, I_2 \ldots I_n$ are the values of subsequent inherent characteristics together with units of measurement.

The steps of the framework of the object's quality measurement on the analytical level are as follow:

1. Identify the requirements at a fixed time.
2. Find type and number of inherent characteristics describing identified requirements.
3. For each inherent characteristic establish unit and accuracy of measurement.
4. For each inherent characteristic provide the value expressed in established unit with established accuracy of measurement.

$$x'_i = \left(\frac{x_i - A}{B}\right)^p, \tag{2}$$

where x'_i is normalized value of x_i, x_i is the value of xi, A, B, p are the

TABLE 2 Selected aggregate functions (F), where β_i is the weight of the i-th standardised inherent characteristic (N_i)

$$F = \prod_i \beta_i N_i \tag{3}$$

$$F = \prod_i N_i^{\beta_i} \tag{4}$$

$$F = \left[\prod_i N_i^{\beta_i}\right]^{\frac{1}{\sum_i \beta_i}} \tag{5}$$

$$F = \sum_i \beta_i N_i \tag{6}$$

$$F = \frac{\sum_i \beta_i N_i}{\sum_i \beta_i} \tag{7}$$

$$F = \frac{\sum_i \beta_i}{\sum_i \frac{\beta_i}{N_i}} \tag{8}$$

$$F = 1 - \sqrt{\frac{\sum_i \beta_i (N_i - 1)^2}{\sum_i \beta_i}} \tag{9}$$

NOTES Adapted from Borys (1991) and Kolman (1973).

parameters, for $p = 1$ it is a linear transformation and for other values of p ($p <> 0$) is a non-linear transformation. A parameter is used to change the range of the features. Most appear on one of the following values: 0, $\overline{x}$, x_{min}, x_{max}. Parameter B serves as a scaling factor (deprives feature of unit) frequently takes on one of the following values: $\overline{x}$, x_{min}, x_{max}, $x_{max} - x_{min}$, S_x, $\sum_{i=1}^{n} x_i$.

In order to apply a measurement on the synthetic level, each inherent characteristic from the X set of values of the object's inherent characteristics (quality pattern) should be additionally completed with a function transforming absolute values to an established range of relative values. In this paper, the scale of relative states by R. Kolman with values from 0 to 1 shall be adopted as an established range of relative values (see table 1). Transformed values shall be designated as x_n. A form of transforming function (N_k) may be expressed with the formula 2. However, this formula has some limitations, as it assumes finite ranges of variability of inherent characteristics. If required, instead of a function equal to formula 2, in order to transform inherent values, one may use a function where the domain is constituted by an infinite set and co-domain by a finite set (e.g. logistic function). Figure 1 presents an example of a function transforming a range (W_{min}; w_{max}) of accepted variability of the object's inherent characteristic. It should be noted that in the given example the limited range of variability of inherent characteristics has caused limitation of the set of values of the transforming function.

In order to obtain a synthetic metric of the object quality, it is

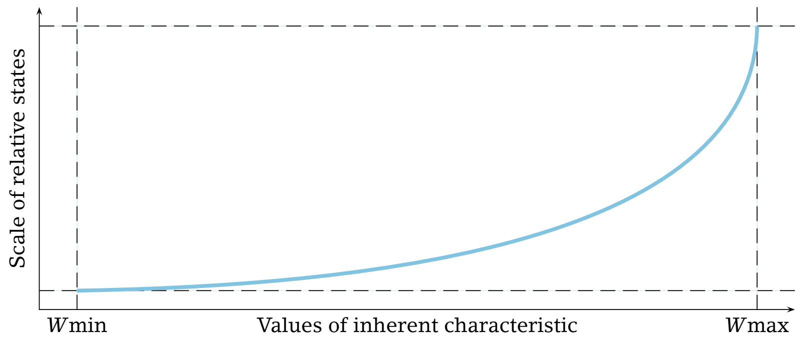

FIGURE 1 Example of a function (N) standardising a range ($Wmin; Wmax$) of accepted variability of inherent characteristic of an object

necessary to apply an appropriate function aggregating partial measurements of inherent characteristics on the relative scale. Table 2 presents selected aggregate functions. The quality of a perfect object on a relative scale may be achieved only when all normalized inherent characteristics equal 1. While using this fact, one may develop a series of aggregate functions based on metrics defining distances in finite-dimensional spaces. To this end, one should deduct from 1 (perfect quality) a distance between the point which subsequent coordinates designate inherent characteristics normalized to the scale of relative states, and the point which subsequent coordinates equal 1. Table 3 presents selected distance metrics in m-dimensional space. Such approach in similarities and dissimilarity measures is not new, for example it was applied in clustering (Gan and Wu 2007, 71–76).

The framework of the object's quality measurement on the synthetic level may be written in accordance with the formula below:

$$\begin{aligned} Q(O, W_j, t) = F[&(N_1(x_1; x_{1\_min}; x_{1\_max}); \beta_1), \\ &(N_2(x_2; x_{2\_min}; x_{2\_max}); \beta_2) \ldots \\ &(N_k(x_k; x_{k\_min}; x_{k\_max}); \beta_k)], \end{aligned} \quad (17)$$

where W_j is the quality pattern, O is the object of the quality measurement, t is the time of conducting the quality measurement, $N_k(x_k; x_{k\_min}; x_{k\_max})$ is the k-th function normalizing results of measurement on the analytical level to the dimensionless scale within the range $< 0, 1 >$, $F((N_1(x_1; x_{1\_min}; x_{1\_max}); \beta_1), (N_2(x_2; x_{2\_min}; x_{2\_max}); \beta_1) \ldots (N_k(x_k; x_{k\_min}; x_{k\_max}); \beta_k))$ is the function aggregating k normalised inherent characteristics $N_k(x_{k\_min}; x_{k\_max})$ with consideration of weight β_k. The formula of the F function should consider a

TABLE 3 Selected distance metrics in m-dimensional space, where $d_{i,k}$ is a distance of point x_j and x_k, $p > 0$

Minkowski distance	$d_{i,k} = \sqrt[p]{\sum_{j=1}^{m} \lvert x_{i,j} - x_{k,j} \rvert^p}$	(10)
Arched distance	$d_{i,k} = \sqrt{\frac{1 - \sum_{j=1}^{m} (x_{i,j} \cdot x_{k,j})}{\sqrt{\sum_{j=1}^{m} x_{i,j}^2 \sum_{j=1}^{m} x_{k,j}^2}}}$	(11)
Squared chord distance	$d_{i,k} = \frac{1}{m} \sum_{j=1}^{m} (\sqrt{x_{i,j}} - \sqrt{x_{k,j}})$	(12)
Bray-Curtis distance	$d_{i,k} = \frac{\sum_{j=1}^{m} \lvert x_{i,j} - x_{k,j} \rvert}{\sum_{j=1}^{m} \lvert x_{i,j} + x_{k,j} \rvert}$	(13)
Canberr distance	$d_{i,k} = \frac{1}{m} \sum_{j=1}^{m} \frac{\lvert x_{i,j} - x_{k,j} \rvert}{\lvert x_{i,j} + x_{k,j} \rvert}$	(14)
Clark distance	$d_{i,k} = \sqrt{\frac{1}{m} \sum_{j=1}^{m} \left(\frac{x_{i,j} - x_{k,j}}{x_{i,j} + x_{k,j}} \right)^2}$	(15)
Angular distance	$d_{i,k} = \arccos \frac{\sum_{j=1}^{m} (x_{i,j} \cdot x_{k,j})}{\sqrt{\sum_{j=1}^{m} (x_{i,j})^2 \sum_{j=1}^{m} (x_{k,j})^2}}$	(16)

NOTES Adapted from Gan and Wu (2007), Schmidt and Hollensen (2006), and Siarry and Michalewicz (2007).

limited substitution of inherent characteristics phenomena. Range $< 0, 1 >$ constitutes a set of values of function F.

The steps of the framework of the object's quality measurement on the on the synthetic level are as follow:

1. Develop a quality pattern at a fixed time.
2. Identify the requirements.
3. Perform segmentation of requirements.
4. Convert the requirements of selected segments into values of inherent characteristics and determine accepted ranges of variability for each characteristic.
5. For each inherent characteristic establish a function normalizing results of measurement on the analytical level to the dimensionless scale within the range $< 0, 1 >$,
6. Select a function aggregating all normalized inherent characteristics. The formula of the function should consider a limited substitution of inherent characteristics phenomena. Range $< 0, 1 >$ constitutes a set of values of selected function.

The adoption of $< 0; 1 >$ scale in the quality measurement on the synthetic level may cause some doubts. What happen when inherent characteristic level is in practice 'better' than requirement? What in practice means 0 on the adopted scale? Referring to the first problem, we need to define what and for whom 'better' level of inherent characteristic mean. Assuming that for stimulant it would be larger than required value, for destimulant it would be smaller than required value and for nominee it would be equal to required value, the result of quality measurement would be still 1. Based on formula (18) and assumption (4) it must be noted that quality measurement on the synthetic level is made with fixed quality pattern (established on the basis of segmented requirements formulated by some units in relation to the object), fixed time of conducting the measurement and assumption that requirements do not have to be constant in time. Let us consider quality measurement on the synthetic level in situation where in some time ($t+1$) consumer (from segment to whom quality pattern was established in time t) was offered an object with inherent characteristic level 'better' than requirement established in quality pattern (fixed in time t). In this case there may be two option, firstly: 'better' inherent characteristic level may be irrelevant from the point of view of the consumer, secondly: requirements have changed therefore quality pattern become outdated and to measure the quality properly new quality pattern is needed.

Referring to the second problem, based on and assumption (3) (requirements may have both different importance and different values depending on who formulates them) quality measurement equal 0 made for the selected segment does not exclude the situation that for a different segment the same object would have higher quality as well as there may be situation that it is the product of different category and even for the same segment but different quality pattern would get higher quality value.

Conclusions

In light of the foregoing considerations, to accept that the quality measurement is a concept so obvious that it does not need to be systematized can not be considered as correct. The use of the framework of quality measurement can help to avoid many mistakes and misunderstandings resulting from the desire to measure the quality without clarifying fundamental assumptions. The adoption of the methodology proposed in this paper allows systematizing quality measurement booth on analytical and synthetic level. Based on the definition of quality contained in the widespread ISO 9000, the proposed methodology for measuring the quality can also be used to interpret the results of other quality measurements. For example, wherever in the results of quality measurement a large variance is observed there may be presumed that there was not properly executed segmentation process.

It seems that the problem of inherent values normalization has been sufficiently described in the literature. The challenge for measuring the quality is still to determine the appropriate aggregate function at the synthetic level of measurement. According to the author of this article may be assumed that there is a whole class of aggregate functions that may be appropriate depending on the type of the object being measured. Moreover, it can be assumed that through the use of scale of relative states, quality measurement results will be widely used in computer information systems.

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Abstracts in Slovene

Definicija poslovnega ekosistema v grajenem okolju z uporabo procesa ocenjevanja deležnikov

Tuomas Lappi, Harri Haapasalo in Kirsi Aaltonen

Akterji in njihovi medsebojni odnosi so osrednji elementi koncepta poslovnega ekosistema, trendovski model poslovnega sodelovanja, ki poudarja organizacijsko raznolikost, razmerje odvisnosti in skupni razvoj. Ta študija se osredotoča na poslovni sistem v grajenem okolju z namenom strukturiranja priznane kompleksnosti definicije ekosistema z uporabo tristopenjskega ocenjevalnega procesa deležnikov. Proces temelji na mrežnem diagramu deležnikov, dobro znanem vodilnem deležniškem modelu in dvodimenzionalni deležniški matriki. Ocenjevalni proces se nanaša na študijo primera šolskega kampusa z namenom definiranja poslovnega ekosistema v grajenem okolju in pomen akterjev ekosistema. Rezultati, vključno z izračunom stopnje pomembnosti, potrjujejo uporabnost predlaganega postopka. Ugotovitve raziskovalcem ekosistemov omogočajo nov način vpogleda v to, kako se koncepti teorije deležnikov lahko uporabijo za razširitev razumevanja dinamike poslovnega ekosistema.

Ključne besede: poslovni ekosistem, poslovanje v izgrajenem okolju, model pomembnosti, ocena deležnikov

Management 10 (2): 111–129

Pravne in vodstvene posledice italijanske »omrežne pogodbe«

Francesco Saverio Massari, Maria Teresa Riggio in Donato Calace

V današnjem času procesi inovacij in internacionalizacije zahtevajo več programiranja in večje investicije v nova znanja in v odnose. S pomočjo trans-sektorskih in trans-teritorialnih omrežij lahko mala in srednje velika podjetja sodelujejo pri globalni dinamiki, še posebej na področju izmenjave in ponotranjanja znanja. Avtorji predlagajo, da »Contratto di Rete« (omrežna pogodba) postane inovativna vrsta formalne pogodbe in osrednja rešitev v teh dinamikah. Od njene uvedbe v letu 2009 na podlagi zakonskega odloka 5/2009, je to novo omrežno orodje postalo zelo uspešno in priljubljeno med italijanskimi podjetniki. Avtorji omogočajo pregled ozadja omrežja in pogodbene teorije, na koncu pa sledi še predstavitev nekaterih najboljših praks preko nazornih študij primerov. Tak pristop združuje pravne in vodstvene perspektive, kar ima koristne posledice za znanstvenike in praktike.

Ključne besede: pogodbe, omrežna pogodba (Contratto di Rete), mreženje, mala in srednje velika podjetja (SMEs), agregacije med podjetji, konkurenčnost, inovacije

Management 10 (2): 131–148

Okvir strateškega učenja: cikel PDCA (plan-do-check-act – načrtuj-naredi-preveri-ukrepaj)

Michał Pietrzak in Joanna Paliszkiewicz

V današnjem času mora biti strateško načrtovanje trajen proces in organizacijsko učenje ga mora podpirati. Raziskovalci v teorijah organizacijskega učenja poskušajo razumeti procese, ki vodijo do sprememb v organizacijskem znanju, kot tudi učinke učenja na organizacijsko učinkovitost. V skladu s tradicionalnim pristopom se strategijo dojema kot enkraten dogodek. Vendar pa v modernem naglo spreminjajočem se okolju to ne velja več. Obstaja potreba po prilagodljivem strateškem upravljanju, ki uporablja procese organizacijskega učenja. Ključni element tovrstnih procesov je pridobivanje informacij, ki omogoča prečiščevanje začetne verzije strateškega načrta. V tem delu avtorja razpravljata o ciklu PDCA kot okvirju procesa strateškega učenja, ki vključuje tako enokrožno, kot tudi dvokrožno učenje. Avtorja predlagata ideje za nadaljnje raziskovanje na področju organizacijskega učenja in strateškega upravljanja.

Ključne besede: cikel PDCA, organizacijsko učenje, znanje, strateško upravljanje
Management 10 (2): 149–161

Ocena tveganja in ocena stroškov v gradbenih projektih z uporabo simulacije Monte Carlo

Claudius A. Peleskei, Vasile Dorca, Radu A. Munteanu in Radu Munteanu

Gradbeni projekti ponavadi zahtevajo precejšnje investicije. Za podjetja to seveda pomeni tvegan podvig, saj predvideni stroški gradbenih projektov skoraj vedno presežejo predvideni scenarij. To je povezano z različnimi tveganji in zato na tem področju vlada velika negotovost. Opredeljevanje in določanje količinskih tveganj in njihovega vpliva na stroške projekta velja za enega izmed najtežjih področij v gradbeništvu. To delo analizira način ocenjevanja gradbenih podjetij z uporabo simulacije Monte Carlo. Raziskuje, če različni stroškovni elementi v gradbenem projektu sledijo določeni verjetnostni porazdelitvi. Raziskava proučuje vpliv korelacije med različnimi stroški projekta na rezultat simulacije Monte Carlo. V njej je ugotovljeno, da je simulacija Monte Carlo lahko uporabno orodje za vodstvene delavce, ki ocenjujejo tveganje in se lahko uporablja za predvidevanje stroškov gradbenih projektov. Raziskava je pokazala, da so stroški distribucije pozitivno neenakomerni in zdi se, da imajo stroškovni elementi nekaj medsebojnih odvisnosti.

Ključne besede: obvladovanje tveganja, simulacija Monte Carlo, gradbeništvo, verjetnostna porazdelitev
Management 10 (2): 163–176

Okvir merjenja kakovosti

Grzegorz Grela

Članek opisuje splošne determinante merjenja kakovosti. Natančneje opredeljuje štiri predpostavke, ki so bile oblikovane z namenom razvoja okvirja za merjenje kakovosti. Te predpostavke so: (1) kakovost je stopnja, do katere skupek svojstvenih značilnosti izpolnjuje zahteve, (2) zahteve in inherentne značilnosti ustvarjajo omejene nabore, (3) zahteve so lahko različno pomembne in imajo različne vrednote - odvisno od tega, kdo jih oblikuje in (4) ni potrebno, da so zahteve časovno konstantne. Članek vsebuje okvir merjenja kakovosti, temelječ na štirih zgoraj navedenih predpostavkah. Predlagani so zapisi o merjenju kakovosti tako na sintetični, kot tudi na analitični ravni. Vsebuje primere izbranih metrik razdalje v m-dimenzionalnem prostoru , pa tudi primere izbranih sestavljenih funkcij, ki se lahko uporabljajo pri merjenju kakovosti na sintetični ravni.

Ključne besede: merjenje kakovosti, vodenje kakovosti, TQM (Total Quality Management – celostno obvladovanje kakovosti)
Management 10 (2): 163–176