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Roger Sweetman
National University of Ireland, Galway, Galway, Ireland., roger.sweetman@nuigalway.ie

Orla O'Dwyer
National University of Ireland Galway, orla.odwyer@nuigalway.ie

Kieran Conboy
National University of Ireland, kieran.conboy@nuigalway.ie

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Roger Sweetman
Lero,
National University of Ireland, Galway
roger.sweetman@nuigalway.ie

Orla O'Dwyer
Lero
National University of Ireland, Galway
orla.odwyer@nuigalway.ie

Kieran Conboy
Lero,
National University of Ireland, Galway
kieran.conboy@nuigalway.ie

ABSTRACT

Portfolio management practices and theory continue to remain focused on a centralized "command and control" perspective. Even though many organizations promote and encourage self-organization, particularly within their software development teams, little is known about how or if IS project portfolios self-organize. Previous studies have explored self-organization at organizational, team, or project level, but do not explore self-organization at portfolio level. Self-organization facilitates the acceptance of innovative ideas and enables autonomous teams to respond to changes in requirements or in the environment without management intervention. This research-in-progress paper aims to firstly contribute to research by using the theory of complex adaptive systems to explain how one aspect of control, namely self-organization, can occur in portfolios of IS projects. Secondly, this study will, through the use of exploratory case studies, contribute to practice by determining the implications and challenges for managers of self-organizing IS portfolios.

Keywords

Project portfolio management, self-organization, complex adaptive systems, control.

INTRODUCTION

Information systems (IS) development projects have suffered from high rates of failure for over 50 years. Projects are characterized by major cost overruns (Jorgensen and Molokken-Ostvold 2006, Conboy 2010), quality problems (Parnas and Lawford 2003) and late delivery (Payne 1995, De Reyck et al. 2005, Jiang and Klein 1999). This "software crisis" (Naur and Randell 1969) motivated McFarlan (1981) to propose a portfolio approach to information systems. Project portfolio management (PPM) enables IS managers to focus on the management of multiple projects by ensuring projects are systematically evaluated, selected and implemented in order to deliver organizational strategy (Jeffery and Leliveld 2004). Effective management of an Information Systems (IS) portfolio is critical to managing risk, achieving business value from IS and also in aligning IS projects to organizational strategy (Kauffman and Sougstad 2008, Reich and Benbasat 2000, Hatzakis et al. 2007, De Reyck et al. 2005). Where IS project portfolio management (PPM) has been practiced effectively, massive savings in cost and time have been realized (LeFave et al. 2008). PPM also has the potential to both reduce the incidence of individual software project failure (McFarlan 1981) and allow successful projects compensate for unsuccessful ones (Costa et al. 2007).

Unfortunately the benefits from adopting a portfolio perspective in IS has failed to match those achieved in other fields, e.g. financial portfolio management (Fabozzi et al. 2002), research and development (Stummer and Heidenberger 2003, Mikkola 2001) and new product portfolio development (Cooper et al. 2001) where portfolio theory has been applied in a more mature and effective manner. IS PPM research has over-emphasized project selection (Meskendahl 2010, De Reyck et al. 2005) and until recently there has been little on how IS portfolios are governed post-project selection (Frey and Buxmann 2012). The limited number of contributions that explicitly address the issue of IS portfolio management focus on the need for a centralized perspective on project management (Frey and Buxmann 2011) ignoring the complex and adaptive nature of contemporary IS portfolios.

Complex adaptive systems theory (CAS) has proven effective in studying complex phenomena in a number of disciplines and is revealing new insights from which project and portfolio management can learn (Cooke-Davies et al. 2008). IS project portfolios can be considered complex adaptive systems. They are complex because portfolios are made up of a large number of interdependent projects and teams and have goals that are ill defined, ambiguous, or subject to change (Bardhan et al. 2004). IS portfolios are adaptive because they must change in order to maintain alignment with a rapidly changing business and technological environment (Merali et al. 2012, Blichfeldt and Eskerod 2008) where organizational strategy, customer demand and user needs change rapidly (Angelou and Economides 2008, Bardhan et al. 2004, Martinsuo 2013). CAS has been applied to general project portfolio management (Perry 2012) and to problems in IS, but has yet to be applied to IS PPM despite practitioner interest (Gartner 2014). An important feature of CAS is the lack of a single point of control meaning that behaviors can be unpredictable making direct control difficult with a subsequent reliance on informal controls such as self-organization (Rouse 2000).

Self-organization has been described as the anchor point phenomenon of complex adaptive systems theory (Tan et al. 2005, Chiles et al. 2004). It can be defined as the spontaneous coming together of groups to perform some purpose. The group decides what, how and when to perform and their activity is not explicitly directed from outside the group (Mitleton-Kelly 2003b). Self-organized teams are able to react to changes in requirements or in the environment and respond without management intervention (McGrath 2001, Uhl-Bien et al. 2007). Little is known about how self-organization occurs in IS portfolios even though contemporary IS projects are arranged around the principles of flexibility and self-organization (Highsmith 2013). Arising from this, this study will seek to answer the following research questions:

1. How does CAS explain the occurrence of self-organization in IS project portfolios?
2. What are the implications and challenges for practitioners of self-organizing IS portfolios?

The next section will present a brief summary of the IS PPM control literature followed by the theory of CAS. Subsequently, we present the CAS framework which will be used as the basis for this study. Our proposed research method is then described. Finally, we summarize the proposed contributions, outline the next steps and identify avenues for future research.

BACKGROUND AND LITERATURE REVIEW

Project Portfolio Management Control

PPM is a key function within an organization (Blichfeldt and Eskerod 2008) that requires managers to use control to influence people to make decisions consistent with the three main portfolio goals: maximizing portfolio value, achieving the right mix of projects, and aligning the portfolio with business strategy (Cooper and Edgett 1997). While many organizations seek means to control portfolios of projects, they admit that these means are not easy to find, especially portfolios with complex projects or interdependencies between projects (Rungi 2010, Bardhan et al. 2004). IS research mostly addresses project control with little known about the control of project portfolios (Korhonen et al. 2014, Hansen and Kræmmergaard 2013). The most notable exceptions are recent studies by Hansen & Kræmmergaard (2013) who identify PPM controls used in one organization and Korhonen et al. (2014) and Martinsuo et al. (2014) who examine how uncertainties in project portfolios can be controlled.

Control is exerted through formal (behaviour, outcome) and informal (clan, self) control modes. In a project portfolio control is more than a scaled up version of single project control. Rather than focusing on detail, portfolio managers should enable individual managers to act creatively and allow projects and teams to self-organize, while maintaining a necessary level of accountability (Aritua et al. 2009). Self-organization, a form of self-control, is where the system evolves, or emerges over time into a coherent form or pattern without any explicit management (Benbya and McKelvey 2006b, Cilliers 2000). Self-organization is highly effective for portfolio management as it allows control to be distributed through the system (Kauffman 1995) with self-organized structures both robust (Cilliers 2000, Levin 2003) and capable of responding to dramatic changes in the environment (Uhl-Bien et al. 2007).

Complex Adaptive Systems

Complexity theories have arisen from attempts in the natural sciences to model natural phenomenon (Gleick 1997). They are concerned with the emergence of higher level order in dynamic non-linear systems where the laws of cause and effect do not appear to apply (Beeson and Davis 2000). Complexity theories differ from mechanistic theories in that rather than assuming a centrally controlled governing structure, order emerges from the interaction between the different entities that populate the system. The three main branches of complexity theory are chaos (Bechtold 1997), dissipative structures theory (Prigogine et al. 1985) and complex adaptive systems (CAS) (Goodwin 1994). CAS is the most appropriate of these theories to act as lens to study IS project portfolios. This is because it is the only one that does not take a macro approach to modelling systems. Instead, it models the phenomena at the micro level using the agents that make up the system. It does not attempt to formulate rules for the whole system rather; it formulates rules of interaction for the individual agents in the system. The IS project portfolio can be studied by focusing on individuals, teams and projects (all of which can be represented as agents) and the interactions between them.

While CAS is defined in a number of different ways, most definitions of CAS involve *agents interacting* in *self-organizing* ways with each other and the *environment* (e.g. Nan 2011, Holland 1992). For example, Benbya and McKelvey (2006a) define a complex adaptive system as a system poised between order and chaos, that not only self organizes, but directs its activity towards its own optimization. Vessey and Ward (2013) define a complex adaptive system as "any system featuring a large number of interacting components that exhibits self-organization and emergence under a certain level of tension, and whose aggregate activity is non-linear" e.g. biological habitats, cities and the internet. However, the definition used for this study is the most all-encompassing one where Holland (1992, 1995) defines a CAS as a system composed of interacting agents, which undergo constant change, both autonomously and in interaction with their environment to produce complex and adaptive behaviors and patterns. These patterns are aggregate behaviors and structures that are not predictable from an analysis of the component parts of the system. Rather, self-organization emerges as agents interact through sometimes simple rules which can change and adapt as experience accumulates and environmental conditions change (Anderson 1999, Holland 1995).

CAS is no longer considered a new theory in organization studies (Anderson 1999). However, its application to IS is more recent. For example, CAS has been applied to IT enabled organizational learning (Kane and Alavi 2007), IT supported team processes (Curşeu 2006), improving IS alignment (Benbya and McKelvey 2006b), the role of IT in the development of bureaucracy (Boisot 2006), and the impact of IT on organizational culture (Canessa and Riolo 2006). Further examples of CAS in IS research include processes for technology use (Nan 2011), IS project management (Xia and Lee 2004) and agile software development (Vidgen and Wang 2006, Jain and Meso 2004). This increasing prevalence of CAS in information systems research led to Merali (2006) describing it as the "emergent domain" in management research. Yet, there has been a greater emphasis on the theoretical aspects of CAS rather than empirical studies. Vidgen and Wang (2009) attribute this to the difficulty in making the abstract principles of CAS suitably concrete for case study research. Therefore, we draw on CAS theory to propose a CAS framework that will explain how self-organization can occur in portfolios of IS projects.

CONCEPTUAL FRAMEWORK

No single framework exists in the literature that comprehensively explains CAS. Instead, there are attempts to mathematically model complex systems (e.g. Kauffman 1993, Boisot and Child 1999); develop frameworks to create adaptive or evolutionary organizations (e.g. Volberda and Lewin 2003, Vessey and Ward 2013, Vidgen and Wang 2006); develop frameworks that provide insights into general management issues (e.g. Snowden and Boone 2007, Cilliers 2000); and finally CAS has been used to explain emergent phenomena in complex organizations (e.g. Plowman et al. 2007). This study treats self-organization as an emergent phenomenon. Therefore, we draw on CAS frameworks from Lewin (1999), Alaa and Fitzgerald (2013) and (Nan 2011) to create a single framework that encompasses the core components of a complex adaptive system (Figure 1), namely, *agents*, *interactions*, *environment*, and *feedback loops*, all of which combine to result in the *emergence* of *self-organization*.

An *agent* is a general term to describe the individual actors or basic entities of action of a complex adaptive system (Benbya and McKelvey 2006a, Nan 2011). For a system to be complex it must consist of a large number of different agents which need not be complex in their own right (Cilliers 2000). For example, in an IS portfolio agents may be individuals, teams or projects with diversity and individuality of the agents making a complex adaptive system stronger (Perry 2012, Holland 1995, Gell-Mann 1994). Agents are governed by behavioral rules or schema (Nan 2011, Gell-Mann 1994) such as norms, values and beliefs that allow them to interpret the environment and the actions of other agents (Argyris and Schön 1997). They are intelligent and capable of learning and adapting (Fuller and Moran 2001) through eliciting feedback from other agents and the environment (Holland 1995) with no single agent controlling the behavior of the system as a whole (Benbya and McKelvey 2006a).

Interactions describe the mutually adaptive behavior of agents (Nan 2011). It is the nature of the interactions, not the agents themselves that determines the behavior of the system. Interactions occur by agents exchanging information, energy or resources (Cilliers 2000). For example, in an IS portfolio project teams are constantly interacting with each other by exchanging resources and information about interdependencies (Angelou and Economides 2008, Kundisch and Meier 2011). Further, interactions between agents may affect the interacting agents (Mitleton-Kelly 2003b) and these interactions often cause them to adapt their rules or co-evolve with each other (Stacey 2002, Mitleton-Kelly 2003a). Even interactions between a few elements can have nonlinear effects that are propagated throughout the system (Holland 1995, Cilliers 2000). While agents may act in a selfish manner, the interactions between them can result in aggregates that improve the system as a whole (Levin 1998). Holland (1992) writes that a crucial characteristic of the interactions between agents is their capacity to anticipate the response of other agents. This anticipation can affect the behavior of the system as a whole even if the anticipated response does not materialize. Finally, interactions can only occur between agents in a system if they are connected. Without connectivity the aggregate behavior of agents would be random (Dooley and Van de Ven 1999).

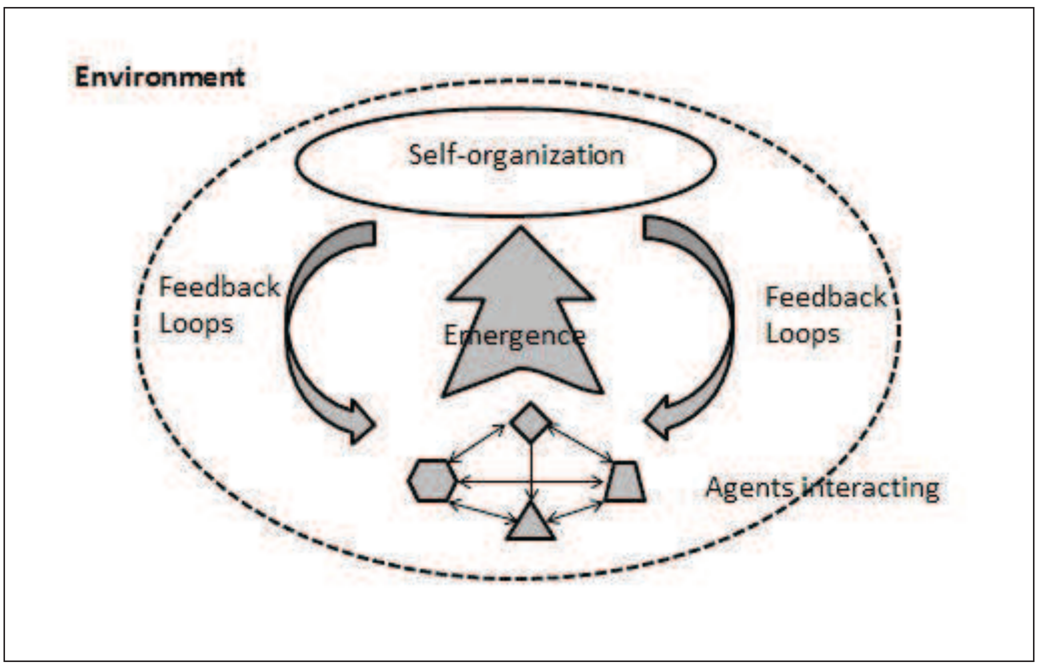

Figure 1. The conceptual framework for this study

The *environment* is the constantly changing setting in which the agents operate and interact. According to CAS theory, a system must be open to its environment. For example, a project portfolio is an open system which exchanges technical information and resources such as skills and people with its environment. It is necessary for a system to be open before self-organization can occur as the emergence of aggregate structures increase the order of a system. This increase in order is not possible unless energy and information are imported into the system and disorder is exported back into the environment (Capra 1996). IS portfolios exist in a rapidly changing business and technological environment (Merali et al. 2012, Blichfeldt and Eskerod 2008) with customer demands and user needs changing frequently (Angelou and Economides 2008, Bardhan et al. 2004). Because the environment is constantly changing, the maintenance of alignment between the IS portfolio and its environment is a key challenge in IS PPM (De Reyck et al. 2005). According to Benbya and McKelvey (2006a) changes in the environment create an adaptive tension stimulating the creation of order within the system meaning any "fitness" is only temporary. Thus, complex adaptive systems are considered to be sub-optimal or operating at a point "far from equilibrium" (Fuller and Moran 2001) with the emphasis on improvement rather than optimization (Holland 1992).

Complex adaptive systems are characterized by the existence of many direct and indirect *feedback loops* (Cilliers 2000). Feedback loops occur where components in the output stage can inform components in the input stage (Andriani 2003). The American school of complexity science sees feedback as the driving force of complex systems adaption (Benbya and McKelvey 2006a) where interrelated parts feed back to each other driving or damping change (Mitleton-Kelly 2003a). Positive and negative feedback loops can co-exist simultaneously (Mitleton-Kelly 2003a). Positive feedback reinforces or amplifies the initial change and can result in a radically altered system. Negative feedback dampens or suppresses the initial change (Mitleton-Kelly 2003a). In a portfolio, desired behavior can be encouraged with positive feedback and unwanted behavior reduced through negative feedback. While management literature often emphasizes the importance of negative feedback for control, emergent behaviors can be better managed with positive feedback that allows and supports autonomous action (Choi et al. 2001).

Emergence is a phenomenon whereby well-formulated aggregate behavior arises from localized individual behavior (Miller and Page 2007). According to Holland (1992) complex adaptive systems exhibit aggregate behaviors that emerge from the interactions between the agents. In emergence "the whole is greater than the sum of the parts" (Mitleton-Kelly 2003a). In an IS project portfolio examples of emergence are higher level structures such as special interest groups and behaviors such as culture. Further, emergence is unpredictable and is immune to reasonable variations in the behavior of individual agents (Miller and Page 2007). From the perspective of a CAS *self-organization* emerges from the interaction of agents with each other and with the environment.

The application of CAS in IS PPM is limited. This study proposes to extend existing research on CAS and IS project portfolio management with a view to explaining how self-organization can occur in portfolios of IS projects and providing new insights for managers on the implications and challenges for managers of self-organizing IS portfolios.

RESEARCH METHOD

While modelling is often deemed an appropriate method for gaining insights into complex systems, Cilliers (2001) warns that models, by necessity, reduce the complexity of a system making a model of complex system flawed by default. Therefore, drawing on the pragmatic IS movement where artefacts are designed "*to be flexible, ready for surprise and suitable for improvisation*" (Niccolini 2013), an interpretivist qualitative approach is proposed for this study. We will use multiple case studies, which is appropriate when a research phenomenon is investigated in its natural setting (Yin 2009). This will provide a rich insight into self-organization in IS project portfolios. The intention is to conduct a number of case studies across a range of industry sectors using a purposeful case selection strategy to select cases that are information–rich (Patton 1990). This will also provide the opportunity to conduct within-case and cross-case analysis. Case study selection will be carefully considered based on the size, business and structure of potential cases (Benbasat et al. 1987). Organizations must be of a sufficient size and have a business model sufficiently supported by IS to ensure at least one complex IS portfolio exists. By selecting sites where contradictory results are expected it is intended to cover different theoretical conditions (theoretical replication) (Yin 2009). Data collection will continue until saturation is reached (Corbin and Strauss 2008).

A traceable 'audit trail' of the research process will be followed to improve the reliability and repeatability of the research. An interview protocol will be prepared based on the main concepts of CAS (agents, interactions, environment, feedback and emergence). Interview questions will be primarily open-ended and designed to elicit examples of self-organization and management challenges with self-organisation. In order to answer the first question we will identify interactions between portfolio agents, interactions between agents and the environment, feedback loops and how each of these leads to the emergence of self-organization in IS portfolios. To answer the second research question we will identify the management challenges and implications of self-organization in IS portfolios. A pilot study with one portfolio manager and one project manager is planned to test the interview protocol. Subsequently, additional organizations and personnel will be identified to participate in primary data collection.

CONCLUSIONS AND NEXT STEPS

This study has a number of limitations. Firstly, while is not possible to generalize the findings of qualitative research, the selection of a broad range of case studies, in order to achieve theoretical replication, ensures the findings are rigorous and provides a sound foundation for future research. Secondly, the use of interviews to collect data is subject to bias by the researcher. We will attempt to avoid this by corroborating information from different participants. Thirdly, participants may not be willing or able to answer questions. In such instances interview questions may be rephrased to elicit a response. Further, all participants will be assured of the confidentiality of the study. Finally, concepts such as self-organization and emergence are abstruse and difficult to identify. We will interview multiple project and portfolio managers in each organization in an attempt to address this and also to improve the reliability and validity of the findings.

The implications for control of the increasing complexity of IS portfolios in organizations allied to the dearth of research examining self-organization in IS portfolios motivates this study. There is little research on IS PPM and this is reflected in the IS field where IS PPM practices are often inadequate. Research has failed to address the gap between the command and control philosophy of PPM and contemporary methods focused on self-organization. From a research perspective, this study will advance our understanding of self-organization in IS portfolios by using CAS as a lens to explain how it can be facilitated. This is a meaningful addition to the literature as little empirical work has attempted to understand self-organization in IS project portfolios. The study will also contribute to practice by identifying the implications of self-organization for portfolio managers who may struggle in complex environments if restricted to using only formal controls.

The next steps for this study are as follows: Firstly, data collected during the pilot study will be analyzed to identify examples of how self-organization emerges in IS portfolios and subsequent managerial challenges. Secondly, a number of additional cases will be identified for the study. Thirdly, primary data will be collected and analyzed using within case and cross-case analysis (Miles and Huberman 1996) to answer both research questions. In terms of future research, there are a number of interesting possibilities. Firstly, the results of this study will make easier to model IS project portfolios as complex adaptive systems using agent based modelling. Secondly, the operationalization of CAS will enable future empirical research into areas such as ambidextrous portfolios, the emergence of culture and the role of feedback in portfolios.

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