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Introduction

Project management theory, and to some extent practice, have tended to focus on process, systems and documents. But projects are instigated, designed and delivered by human beings. This book focuses on the people involved in projects. It conceptualises the project as a social network, or more accurately, multiple layers of social networks, each network dedicated to the delivery of a particular project function. One of the exciting discoveries during the research that this book draws upon was the importance of self-organising project networks, particularly in complex projects. In this book, I explore some of the factors that affect the behaviour of individuals as project actors, including game theory and personality type. I also consider the environmental and personal attributes that might enable networks to function more effectively, particularly in the context of the project. I look at Building Information Modelling (BIM), because there is an important link between the efforts being made in relation to BIM, and social networks. Finally, the book presents some case study material related to a two-year research project which I led involving the Centre for Organisational Network Analysis and Transport for London.

The previous book in this series – *Social Network Analysis in Construction* (Pryke, 2012) – presented social network analysis (SNA) as an innovative method for the analysis of project organisations. It rationalised the SNA approach, looked at the importance of collaborative relationships in project organisations and proposed a theoretical framework to support the conceptualisation of the project as a network of relationships – contracts, information flows and financial incentives. The book proposed a model for the use of SNA which others might adopt in their research and presented four case studies, comparing collaborative, relationship-based procurement and traditional strategies for procurement. The book provided an insight into the interpretation of network data derived from project-based organisations and finally took a somewhat speculative look at how networks might be managed.

It was the chapter on managing networks that was in my view the most innovative, and *Managing Networks* aims to develop that theme using case study material gathered from recent research carried out at the Centre for Organisational Network Analysis at University College London (CONA@UCL). The raison d'être of CONA is to explore the void that is evident between procurement, systems and organisational hierarchies.

In our projects, we set about procuring resources, place those resources in structures that are often expressed either hierarchically or to a high level of abstraction, and then try to manage the self-organising networks of human relationships that evolve, without

conceptualising those relationships as networks. It is little wonder that we often find it difficult to analyse why some projects seem to be successful and others less so. A small group of those associated with CONA@UCL set about trying to classify, and to some extent quantify, organisationally, the 'good' projects and the 'bad' projects, using the language of the social network analysts. Examples of this work are: Badi and Pryke (2006), Badi *et al.* (2014), Badi *et al.* (2016a and 2016b), Doloi *et al.* (2016), Pryke *et al.* (2017), Pryke *et al.* (2015a and 2015b), Pryke (2014), Pryke *et al.* (2014), Pryke *et al.* (2013), Pryke and Badi (2013), Shepherd and Pryke (2014), El-Sheikh and Pryke (2010), Pryke (2005a and 2005b), Pryke and Pearson (2006).

So, this book aims to respond to the needs of several groups: those who ask what the social network theory of project organisations is; the practitioners who ask 'how can I use social network analysis to run smarter projects'; the students who ask how we can start teaching project management in a way that helps them to identify network and actor characteristics – to classify project coalition activity and the actors involved in network terms and to start to build toward defining management in a project-based environment in network terms.

The analysis and representation or visualisation of project-focused activity has involved task-dependency-based approaches, structural analysis (hierarchical) and process mapping, all of which fail to reflect the relationships that deliver our projects – relationships that we can classify by project function.

Structure of the Book

Chapter 2: Theoretical Context This chapter locates the concept of managing networks within a context of managing projects and their supply chains. A number of assumptions have been made about the nature of projects around which procurement and project management practices have evolved. I argue in Chapter 2 that our choice of procurement and the subsequent project management strategies applied have not kept pace with the complexity of many projects. It is also argued that at the point where procurement is completed (and resources identified and secured) a transition occurs where those resources have to configure themselves into systems that will deliver a successful project. We know little of how these self-organising systems evolve. Our lack of awareness means that we typically do not facilitate or manage these systems.

The chapter reflects on the vestiges of scientific management that still remain in project management research and practice. The fact that our projects are delivered by unpredictable, sometimes irrational, imperfect human beings seems sometimes to be ignored in our discussion about programming, risk management and the whole range of sub-systems that we typically bring together in project management. The chapter concludes by pointing to the fact that our highly-connected lives no longer rely on distinguishing task and social structure. Human beings essentially get things done through links to other human project actors. The idea that everything that does not constitute a formal direction or instruction under the terms of the contract should be classified as 'informal' is firmly rejected. There has, perhaps, been some confusion between informal and recreational ties. Although recreational ties are undoubtedly fascinating and important, this book does not deal with them.

The chapter provides a context and perhaps rationale for the chapters that follow. The key themes are developed in more depth in these subsequent chapters.

Chapter 3: Networks and Projects This chapter starts with the reflection that the last fifty years have brought only modest progress in our understanding of ‘systems... functions...interrelationships, and the location and prominence of...control and coordination centres’ (Higgin and Jessop, 1965: 56). In fact many of the techniques that we use to manage projects seem to ignore all of these issues. The chapter makes a start on the formulation of sub-systems that might be studied to enable a better understanding of how projects are *really* managed. The concepts of ritualistic behaviour and routines are introduced and I reflect on the fact that individuals are attracted to routines because they provide consistency and stability, and reduce mental effort (Becker, 2004).

This chapter refers to Morris’ (2013) discussions about the maturity of project definition, or more accurately the tendency for project definition frequently to be insufficiently mature at the point of transition between pre- and post-contract stages. The idea that this uncertainty, exacerbated by continually increasing complexity, leads to project actors forming networks to secure information, solve problems and disseminate processed information is introduced and rationalised. It is argued that at the transition from resource procurement to project delivery, routines are not adequate in the face of complexity in both task and structure. I ask the reader to move on from discussions about the ‘iron triangle’ for the reasons that: it is very difficult to define client needs at a stage early enough to use procurement successfully; it is difficult to avoid agency problems in procurement and delivery; and, arguably, change in project definition *improves* value to client and end-users, rather than the reverse. It is not possible to allocate project and supply chain roles accurately and to maintain these roles as a constant throughout the entire project design and delivery period. Project systems are iterative and transient and this is to a great extent not reflected in the contractual relationships established through many procurement approaches.

The chapter provides an introduction to project actor characteristics (drawn from Pryke, 2012), and an overview is given of network characteristics (path lengths and density) and linkage characteristics (tie strength or value and direction). The chapter ends with a reflection on the question posed – why networks? – and makes a link to Chapter 4. The chapter concludes that the identification and analysis of interaction networks between the individuals engaged to deliver a project is the only way to observe the self-organising, complex project function-related networks that hold the key to understanding successful and unsuccessful project delivery. If we can understand and map these networks, we can define the actor roles and network configurations that constitute successful project delivery and begin to replicate and eventually to manage these networks.

Chapter 4: Why Networks? The chapter starts with some discussion about the origins of SNA and references to Nohria and Eccles’ (1992) work on rationalising the use of SNA in organisations. I emphasise that in a project environment it is important to distinguish between the two types of actors: individuals and firms. Contracts are established between *firms* and projects are delivered through relationships between *individuals*. I discuss some of the issues to be considered when applying SNA to project and supply chain research – the quantitative/interpretative paradigm; the issue of causality and the complexity of SNA as an analytical approach; the importance of precise network classification; and the limitations arising from sampling. Studying and

managing projects that are highly complex in terms of technical content, as well as process, inevitably leads to complexity in both analysis and management approaches.

Some basic SNA terminology is discussed as a preamble to the analysis and discussion in later chapters. A structure for the analysis of projects (and in particular construction and engineering projects) is introduced. I suggest that while traditional project management analytical tools and management approaches essentially pursue the 'iron triangle' of cost, time and quality, clients' and stakeholders' needs are sophisticated and complex, requiring a more finely-grained approach to both analysis and management.

I end this chapter with a call for more research using SNA in projects and provide some details about suitable software and the identification of network boundaries for research.

Chapter 5: Self-Organising Networks in Projects In this chapter I further develop the theme that procurement and project management strategies have not kept pace with rapidly increasing complexity in projects. I discuss the increased prevalence of temporary, project-related organisation forms in a range of industries. Film and software tend to be highly creative but construction and engineering are perceived to be more routine-based. Yet this is contentious and many involved in major construction and engineering projects would emphasise the need for creativity in finding design solutions and in problem-solving. The chapter considers what clients want from projects and although many clients may not express it in those terms, 'completeness' is felt to be of primary concern to most clients. I assert that the previous focus on the iron triangle in the context of financial incentive for designers and constructors is dysfunctional in terms of the client's needs and leads to ritualistic behaviour by project actors. In this context, the chapter moves on to focus upon what I refer to as some 'dangerous assumptions'.

These dangerous assumptions move in chronological order through project procurement and delivery, starting with the definition of client needs. The definition of clients' needs, the difficulty of achieving an accurate representation of those needs in documentary form by human or technological means, the fact that changes in project definition have been regarded as undesirable, and the accuracy and sustainability of role allocation in a long-term, uncertain project environment, are all discussed as possible reasons for our misunderstanding the reasons for failure in project design and delivery.

The discussion turns to the evolution of project management over time and I move through production orientation, functional management, information processing and my own work with Smyth on the relationship approach (Pryke and Smyth, 2006). I ask the question that I frequently put to practising project managers and postgraduate students – 'why does it matter how we conceptualise the project?' I emphasise the need to find a means of understanding the 'non-linear, complex, iterative and interactive' processes that projects constitute (Pryke, 2012). If we can be clear how we conceptualise projects, we can be clear about the way in which we understand and monitor projects and formulate an effective means of managing those projects.

The chapter closes with some case study findings which conclude that:

- Self-organising networks form quickly when project actors are under pressure to gather and disseminate information
- Some actors place themselves into prominent positions for personal reasons that are detrimental to the delivery of the project

- Although at contract placement stage, typically the client formally enters a lump-sum contract, much of the design of the construction project has still to be done, which carries uncertainty (and particularly financial uncertainty) for the client
- Short path lengths between the client and Tier 2 subcontractors are useful in terms of managing design evolution and maintaining knowledge transfer
- Large, confident clients will internalise risk if this is the most effective way to deal with risk, not hesitating to involve themselves with Tier 2 subcontractors to resolve design issues and minimise risk.

Finally, I suggest that we will manage projects more effectively if we conceptualise them as networks of actor relationships.

Chapter 6: Game Theory and Networks The chapter starts with a discussion of the transition between resource acquisition and project delivery. Roles are allocated to individuals as project actors through contracts, but as soon as work starts, whether it is design or production of some sort, actors acquire roles that are related to their network position and network role (for more detail on the latter refer to Chapter 9, Pryke, 2012). The behaviour of individuals as project actors is a function of their network role. Project actors are also influential in network terms – their behaviour affects the way in which the network functions and modifies the behaviour of other project actors.

Social network analysts frequently place relatively low emphasis on the characteristics of human actors, preferring to map network configurations and characteristics alongside the characteristics of the links between actors. In this chapter I remind the reader that human beings are more than simply ‘human resources’ to be placed within a system. Game theory helps us to understand how human actors behave in certain environments – with their behaviour being perhaps unpredictable or even irrational.

Chapter 6 provides a little history about game theory and then reviews the research carried out on the application of game theory to construction projects. The chapter looks at the definition of game theory and discusses case study material which illustrates the way that actors (or in the game theory context, ‘players’) make decisions in relation to the risk context in which they find themselves. The subjects of ‘payoff’ and completeness of knowledge about the game and the players are discussed, and it is noted that the study of game theory environments involving low levels of knowledge about the structure of the game and the payoff is developing into a field of study in its own right. Finally, the link between the behaviours of individuals and the theory is made. Cooperative or collaborative game theory is distinguished from non-cooperative or competitive game theory – and perhaps this distinction sits at the heart of the difference between collaborative project behaviours and opportunistic project behaviour.

I discuss some of the benefits of applying game theory to project networks. These include: the importance of finding some sort of equilibrium following adaptations to environmental factors; the fact that decisions made by individuals reflect past decisions by other actors; and the operation of incentive design in encouraging self-interested human beings to behave in a way that maximises the benefit that a given network might have in delivering a given project. Complexity and rationality are important factors in this discussion about game theory and networks.

I apply game theory to the information exchange network and its evolution and decay. We also return to the five dangerous assumptions put forward in a previous chapter to see how game theory might be used in that context. I conclude the chapter

by asserting that game theory is relevant to the concept of managing networks in a project context through:

- Calculation of payoff and self-interests
- The accuracy of knowledge about the game, the players and the environment
- The identity and behaviour of all other players
- Games played in low levels of knowledge
- The rationality of players
- The importance of the external environment and the fact that this does not prevent players from selecting a particular strategy.

Chapter 7: Network Roles and Personality Types Little has been written about personality type in the context of networks (with the possible exception of Mehra *et al.* (2001), which took a rather specific aspect of personality type). Very little indeed appears to have been written linking project networks with personality type. Chapter 7 was intended as a thought-provoking and speculative discussion about the topic of network roles and personality type, with a view to developing some theory and an agenda for future research.

The chapter recaps on the main actor types found in projects (these were dealt with in more detail in Pryke (2012)). I then outline the aspects of personality identified in personality trait theory.

The discussion turns to the use of humour in networks. Long and Graesser (1988) offered a classification of humour based upon an analysis of television shows and the audience reaction to them. They offer the following classifications: irony, satire, sarcasm, overstatement and understatement, self-deprecation, teasing, replies to rhetorical questions, clever replies to incongruous statements, double entendres, transformation of frozen expressions, and puns. Having explored the terminology of humour, the discussion turns to an exploration of the ways in which humour might help in project-based networks. I ask why humour is associated with leisure and not work, despite findings from Martin's (2007) research that humour results in higher levels of happiness and better health, creative thinking and problem-solving in the workplace. I conclude that more work needs to be done to establish the effects of humour in the workplace and specifically in the project network environment.

There is a discussion about cohesiveness and humour; specifically how humour might build better links between actors in project networks over time. Conversely the subversive effect of negative or critical humour is discussed. Dwyer (1991) noted that the relative power of an individual is reflected by who the joke teller is, who the target of the joke is and who laughs.

I offer a formulation of a 'network person' – behaviours that enable networks to function well.

I then review the behaviours in the context of the personality traits identified earlier in the chapter and particularly in relation to the main project network actor types. I conclude that personality type and behaviour are not commonly associated with network analysis but suggest that the combination could be important in understanding how it is that some project networks appear to be very effective, while others appear to find difficulty in delivering successful projects.

Chapter 8: Network Enabling The chapter starts with a reflection on the types of relationships that we find in the project environment – essentially interpersonal

relationships within the firm and between firms, and inter-organisational relationships which in the project context tend to be dyadic contractual relationships. While the sister publication to this book (Pryke, 2012) covered both interpersonal and inter-organisational relationships, this book focuses on *interpersonal* relationships within and between firms.

The case is made for consideration to be given to the environment in which the networks being studied are operating. Although environmental issues potentially represent unwanted variables in the context of the analysis of network data, if we are to use SNA to deliver better projects, these environmental issues need to be considered. The chapter suggests that alongside the environmental issues noted above, certain factors influence the evolution, maintenance and eventual decay of interpersonal networks. These factors are:

- Trust – the existence and maintenance of trust
- Empathy – the ability to place ourselves in the position of others and to relate to that position and the constraints and anxieties associated with it
- Reciprocity – the extent to which individuals are willing and able to respond to efforts made by others, to provide advice or project information, for example
- Favours – the willingness to grant favours to others, regardless of previous reciprocal activity
- Generosity – the context for reciprocity and the granting of favours.

Set against these positive influential factors are: competitiveness, narcissism and egotism. These are frequently present in networks that appear to operate inefficiently for otherwise inexplicable reasons.

The chapter looks at the environmental conditions affecting interpersonal networks and reflects on the factors that have a positive impact on network evolution, maintenance and decay, as well as those factors having a negative impact. I conclude that good network behaviour is contagious. The pursuit and encouragement of behaviour that promotes trust, empathetic behaviour, reciprocity and generosity are fundamental to improving network performance. Ironically, behaviour that tends to improve career advancement, including appointment to organisations, is the very behaviour that creates difficulty in forming and maintaining communication networks.

Chapter 9: Project Networks and BIM In Chapter 9 I acknowledge that only weak links exist between organisational network analysis and building information modelling, both in terms of research and practice. The chapter links back to the ‘five dangerous assumptions’ identified earlier in the book. In particular, it is noted that projects do not always accurately interpret clients’ wishes, for a range of reasons.

The chapter deals with a brief history of the term ‘building information modelling’ from its early beginnings in the mid-1980s. The development of software providing the third dimension alongside the first two dimensions and subsequently adding cost and time is discussed. BIM is discussed alongside its more generic cousin, information management, and I reflect on the location of highly specialised design expertise associated with technically complex projects and the effect that this relocation of knowledge and expertise has upon the procurement of design and the systems through which we monitor and manage design.

The chapter moves on to consider liability for and ownership of design, and responsibility for design coordination. Intellectual property rights are also identified as an

important factor in the successful implementation of BIM. The effect of organisational structure and information technologies are dealt with through reference to the work of Whyte and Levitt (2010). Coordination is clearly an issue and social interactions are an important aspect of this coordination. BIM is frequently regarded as a 'clash detection' system, ignoring its potential for managing and modelling design along with cost and time parameters. The question is raised as to the potential effect of the full implementation of BIM on contractual 'completeness' and the consequent effects on contractual disputes and their resolution. The question whether BIM is an artefact in the context of the project or the system through which the project is designed is raised.

I conclude the chapter by suggesting that SNA and BIM are theoretically complementary. I acknowledge the work of Al Hattab and Hamzeh (2015) but suggest that research is needed on nodal characteristics; network actor roles; comparison between the three types of centrality measures for project actors; network topography; and, finally, cluster identification. This chapter aims to promote discussion and develop a research agenda in this area, given the relatively little research that currently exists.

Chapter 10: Introduction to the Case Studies This chapter provides a description of the project from which the three case studies were taken. The project comprises a rail infrastructure interchange upgrade costing approximately £600 M at the time of going to press. The chapter deals with some of the particular challenges of gathering network data in a busy design project environment.

Chapter 11: Case Study 1 This case study principally dealt with the application of community detection in social networks – relatively small clusters of actors with relatively high density, embedded within a network context of lower levels of network density. This approach to the analysis of a large and complex project – complex both technically and organisationally – challenged some of the traditional views about how projects should be procured and how they proceed. The research found, inter alia, that decision-making and problem-solving are important in the way in which project actors execute their design roles. In particular the coordination function is prominent when we look at actor relationships in the design phase. The chapter concludes that there is a gap between what is routinely procured in terms of roles and the roles that are acquired through project actors' network positions.

Chapter 12: Case Study 2 This case study looks at the concept of 'dysfunctional prominence'. The data were gathered from the same large rail infrastructure project used in Case Study 1. I discuss the relative merits of point, eigenvector and betweenness centrality in analysing complex projects. The comparison of the values for centrality generated by using these three measures enables us to identify actors who hoard information unnecessarily in information exchange networks. In this case the dysfunctional prominence was identified coincidentally with management interventions to resolve matters. A study carried out at an earlier stage in the project could have identified the trend toward the inappropriate hoarding of project information and enabled earlier intervention. I argue that dysfunctional prominence is a risk to all information exchange project networks and is related to personality type.

Chapter 13: Case Study 3 In the third and final case study I reflect upon the static nature of the roles and responsibilities allocated through project procurement. I consider the cost of network evolution over time and suggest that this is an aspect of project networks that is in its infancy. The case study took the Barabási and Albert (1999) and Erdős and Rényi (1960) models for network evolution and applied these to the case

study project using data on actor cost per day. The chapter concluded that it is potentially very useful to profile network evolution and decay costs in the project context. There is a period in the evolutionary cycle of a project network between 2 and 20 actors where scaling costs are disproportionately high. This suggests that project managers should consider network interventions in those early stages of network evolution to enable connections to be formed quickly and effectively, thus helping to reduce the disproportionate cost of network evolution. I suggest the establishment of a network broker team, whose role it would be to facilitate information exchange linkages and to diffuse disputes over role negotiation between project actors.

Chapter 14: Summary and Conclusions In the final chapter I synthesise the twelve preceding chapters and draw out the key arguments and conclusions developed in this book. The theory is developed and some speculative discussion associated with future research agendas is set out. I reflect on the three case studies, which provide a small sample of some of the findings of a two-year research project which was completed just before publication of this book.

I hope that this overview of the book will encourage the reader to dip into particular areas of interest. For those with no background in social networks, the previous book, *Social Network Analysis in Construction* (Pryke, 2012), is recommended as a precursor to this book.

