AN ECOLOGICAL PERSPECTIVE ON INNOVATION MANAGEMENT

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Abstract

Enabling innovation is major challenge for individuals, teams, organizations, regions and economies and the topic is increasingly seen as being crucial not only to success but to survival. The topic of innovation is both complex and wide-ranging and has not been extensively explored in the information systems literature. Many IS scholars such as Swanson and Ramiller, Fichman, Avergou and La Rovere, and Lee have implied that an ecological approach is required to refresh research in this important area. The purpose of this paper is to adapt the ecological systems theory (EST) of Urie Bronfenbrenner and apply it to a case study of innovation in a subsidiary of APC (by Schneider) located in the west of Ireland. Furthermore the paper involved utilising a new form of action research called dialogical AR recently proposed by Mårtensson & Lee. Among other findings the study shows that the EST lens can provide a comprehensive analysis of the innovation ecosystem which takes account of both internal capabilities and external influences.

Keywords:

Ecological system theory

Innovation and information systems,

Dialogical Action research

1 INTRODUCTION

Innovation is critically important to organizations, regions and economies and the topic is increasingly seen as being crucial not only to success but to survival. The topic of innovation is both complex and wide-ranging and has not been extensively explored in the information systems literature (Avgerou, 2003). Addressing this situation presents a number of challenges such as: agreeing a definition of the concept, making sense of the voluminous literature from eclectic sources, and examining information systems both as innovations *per se* and as enablers of innovation. Many questions increasingly exercise the minds of managers, entrepreneurs, policy makers and academics as they grapple with this perennially important topic. These include reasons why an innovation is successful in one organization and met with resistance in another and how it is that certain innovations diffuse easily through an environment while others do not. After almost half a century of intense research and theorizing, the academic contribution to answering questions such as these is less than convincing (Fagerberg, 2005).

The location of the study is Ireland which still punches way above its weight internationally by attracting 2% of total global foreign direct investment (FDI) in 2008 which amounted to circa €2 billion (IDA, 2009). The focus of the IDA (Industrial Development Authority which is responsible for foreign direct investment in Ireland) is on three strategic pillars: Global Services, High Technology Manufacturing and RD&I (Research Development and Innovation). Consequently innovation in manufacturing processes is a vital ingredient to providing sustainable MNC (Multinational Corporation) subsidiaries in the country. Ireland's policy makers have the strategic aim of growing an innovation economy.

The work is presented in the context of a two year case study of innovation in APC Ireland, a subsidiary of the critical power and cooling services division of the Schneider Electric Corporation. One of the researchers was given access as a temporary employee for the duration of the project which involved getting a company badge and being admitted to the company's information systems as well as having an APC email account. Furthermore the paper will describe the utilization of a novel form of action research recently proposed to the IS community by Mårtensson & Lee (2004) which they call *dialogical AR*. The central aim of this paper is to answer the following research question: can ecological systems theory illuminate the study of innovation in this context? It proposes to make a novel contribution by introducing ecological systems theory to the examination of information systems innovation. The paper is structured as follows. First a synthesis is presented of the innovation literature together with an overview of the theoretical framework. Following this an outline of the case study and the research approach is described. Then the case is analysed through the lens of ecological systems theory. Finally the conclusions are presented and suggestions for future work.

2 BACKGROUND

This section will initially provide a brief overview of the concept of innovation as it pertains to this study. Then we will examine innovation as it relates to the IS literature and consequently argue that the subject is ripe for a new theoretical formulation to progress research in the area.

2.1 Innovation Studies

Many scholars trace the introduction of innovation into the realm of economic and social change to Joseph Schumpeter's seminal work on the "Theory of Economic Development" (Schumpeter, 1934). In this work he classified innovation into five categories: new products (or goods), new methods of production (or processes), new sources of supply (or half-manufactured goods), the exploitation of new markets, and new ways to organize business. In Schumpeter's original schema, innovation is accomplished by "entrepreneurs" who developed new combinations of existing resources (Swedberg, 1991). However, in his later works, he came to regard the large corporation as the innovative engine driving the development of leading economies (Lazonick, 2005). Fagerberg (2005 p 4) makes the fundamental distinction between invention and innovation where the former is regarded as the "first occurrence" while the latter is the "first attempt to carry it out into practice". This is in line with Van de Ven's (1986 p 604) assertion that "an invention or creative idea does not become an innovation until it is implemented or institutionalized" . Storey (2004) points out that debate on the very meaning of the term innovation has been controversial and problematical. One of the main challenges of a review of innovation is the range of definitions from a wide body of literature. In their analysis of the terms *innovation* and *innovativeness* from 21 empirical studies in the new product development (NPD) literature, Garcia *et al.* (2002) discovered that "no less than fifteen constructs and at least 51 distinct scale items" were used leading to a great deal of ambiguity (p.110). The Minnesota Innovation Research Program (MIRP) resulted in important pioneering work on innovation and its publications are generally known as the Minnesota studies (Van de Ven et al., 2000). The MIRP program was carried out by approximately 40 researchers, now scattered among faculty across the globe, who conducted longitudinal studies of 14 innovations during the 1980s. Four basic factors are implicit in their work: new ideas, people, transactions and institutional context. The increasingly important role of academia in supporting innovation in knowledge-based societies has led to the development of a number of models from national systems of innovation (NIS) (Lundvall, 1995) to the more recent Triple-Helix model of university-industry-government relations (Etzkowitz & Leydesdorf, 2000). The fragmentation of organizational boundaries by, on the one hand the move towards open and user-lead innovation (Chesbrough, 2003; von Hippel, 2005) and on the other hand, the development of social networking and networks of practice (Whelan, 2007) is currently the subject of growing academic interest.

The main point from this brief overview is to provide a basis for our argument that the study of innovation is a complex, multi-dimensional phenomenon with dynamic interactive characteristics that invites a novel theoretical framework. We will now turn out attention to innovation within the information systems literature.

2.2 Innovation and Information Systems

In this section we initially make a basic distinction which we believe is essential when approaching the topic innovation vis-à-vis information systems. The first one we term *innovation in IS* and the second as *IS in innovation*. The former we develop from Swanson's (1994) generic definition of a process innovation as "any new way of developing, implementing and maintaining IS". The latter we express as: the role of IS in supporting innovation. In connection with *innovation in IS*, Swanson (1994) argues that current innovation theory had done little to explain IS innovation and where it stood within the ct of rigour we adopted the five principles proposed by Davison et al. ‼ ADDIN EN.CITE <EndNote><Cite
on with the innovation core sandwiched in a swiss-roll arrangement between the inner technical core and the outer administration core. A subsequent empirical testing of the model resulted in "cautious optimism" but suggested a need for further theoretical work to refine, elaborate and extend the system (Grover et al., 1997). In a subsequent influential paper, Swanson and Ramiller (2004) start by defining IT innovation as the process by which "IT comes to be applied in novel ways" and conclude that the literature on bandwagon phenomena indicate that much supposedly innovative behavior is actually "me too" activities. Their call for an enlarging of the IS academic research to "investigate the cognitive processes of organizations" and to engage with the *psychological* as well as the organizational literature has relevance for the present study. Fichman (2004) takes the concept of *mindfulness* with six others (innovation configurations, social contagion, management fashion, technological destiny, quality of innovation and performance impacts) and presents them as emerging perspectives that can take IT innovation research beyond its present *dominant paradigm* which he believes is showing signs of exhaustion.

Other scholars, albeit a minority, have taken a different approach when viewing innovation and information systems. In this case they have explored the role, both positively and negatively, of what we term *IS in innovation*. For example, the work of Tarafdar et al. (2005) examines how a firm's information technology (IT) capabilities affect its ability to innovate. They explain that the IT capability of the firm has five dimensions: IT Infrastructure, IT Human Resources, IT-related Intangible Resources, IT Coordination and IT governance. On a more general level, Pavitt (2005) argues that ICT can support innovation by reducing search and selection costs and digitalization has resulted in systems of increasing complexity. Dodgson *et al.* (2005) propose that a range of new technologies such as: simulation and modeling tools, virtual reality, data mining and rapid prototyping have lead to the *intensification of innovation*. They have used an umbrella term – innovation technology (IvT) to describe these new tools and methods. IvT they argue is being increasingly applied to innovation and indeed is dramatically changing the nature of the innovation process. Furthermore they contend that IvT is having a significant influence on accomplishing creative tasks and on defining the ways in which knowledge is constructed, shared, and used. A number of IS scholars have implied that an ecological approach is required to view information systems innovation. Swanson & Ramiller's (2004) conclude that research into organizational innovation must take cognizance of the broader institutional context. They also call on researchers to examine the psychological as well as organizational literature. Fichman (2004) suggests that the current *dominant paradigm* in IT innovation research has reached the point of diminishing returns and urges researchers to investigate more radical methods and concepts to refresh the research agenda. Lee (Lee, 2001 p 241) rejects the "objectivist ontology" that knowledge (which we consider fundamental to innovation) can exist independently of knowing subjects. Ciborra (2002) argues that the position of ICT in

organizations requires a shift from the present focus on the *scientific paradigm* to an "alternative centre of gravity: human existence in everyday life" (p. 1). Avgerou and La Rovere (2003), in their endeavor to open a dialogue between research on information systems and the economics of innovation, have challenged the IS community to rethink "long-established disciplinary divisions and conceptual categories" (p. 206) .

Now we will proceed to outline the theoretical framework that is used to analyse this case study.

2.3 Theoretical Framework

Urie Bronfenbrenner spent most of his professional career as Professor of Human Development, Family Studies and Psychology at Cornell University. His development of Ecological Systems Theory (Bronfenbrenner, 1979) is regarded as having revolutionized studies in these areas by shattering barriers and building bridges among the social science disciplines. Previous to Bronfenbrenner's work, the study of human development was compartmentalized among psychology, sociology, anthropology, economics and political science. However, through the concept of the ecology of human development, these disparate environments were integrated into a holistic conceptual framework of interdependent nested systems where human development was viewed as a continuum (Lang, 2005). Bronfenbrenner viewed a "child's development within the context of the system of relationships that form his or her environment" with each complex "layer" influencing the development (Paquette & Ryan, 2001). His own conception of the theory was as "a set of nested structures, each inside the next, like a set of Russian dolls"(Bronfenbrenner, 1979 p 3). He acknowledges the debt he owes to the theories of Kurt Lewin who expressed behavior as a function "of the interplay between person and environment" in the form of a classic equation shown below. Furthermore, Bronfenbrenner affirms that his theoretical framework originated from Lewin's antecedent work that places behavior in context: "-situational, interpersonal, sociological, cultural, historical- and above all theoretical" (Bronfenbrenner, 2004 p 43) p. 43.

$$B = f(PE)$$

Lewin's well-known formula expresses *behavior (B)* as a combined *function (f)* of forces from within a *person (P)* and from the external *environment (E)* (Jackson, 1998 p 44).

Bronfenbrenner argued that Lewin's formulation did not include a time dimension and proposed his own version of the equation for the area of human development. Here development is regarded as a function of the person interacting with the environment which includes the effects of both constancy and change (the time dimension) on personal characteristics throughout the life span (2004 p 108) which is captured in the following equation.

$$D = f(PE)$$

Bronfenbrenner affirmed that a major motivation for his work was to provide both psychological and sociological depth to Lewin's theories. From an IS viewpoint it is significant that he claimed his theory differed from antecedent research models in that he analyzed the environment in *systems* terms. His theory is shown diagrammatically in Figure 1.

Cranefield and Yoong (2007) in a recent debate on the perennial subject of the *relevance* of IS research, proposed that ecological systems theory can enrich our understanding of IS practice by providing a more holistic view of the area . They built their thesis mainly on McLeroy *et al.*'s (1988) work on an ecological perspective for health promotion programs which had transposed the original work of Urie Bronfenbrenner to that discipline. Acknowledging our debt to the suggestion of Cranefield and Yoong, we now go to the sources of Bronfenbrenner's main work (1979; 2005) and propose a modified framework for the area innovation and information systems.

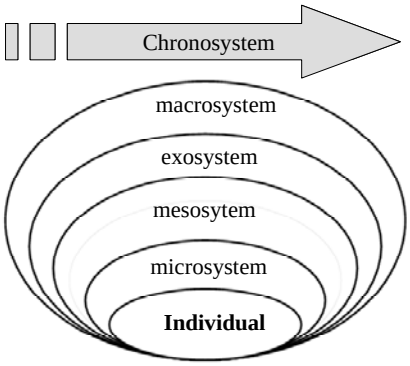

Figure 1: Ecological Systems Framework –adapted from Cranefield &Yoong (2007)

We will initally describe each nested layer of the modified Bronfenbrenner model where the "patterned behavior" is determined by the following:

- Individual level: Intrapersonal factors-characteristics such as knowledge, attitudes, behavior, self-concept, skills etc. It also included the developmental history of the person.
- Microsystem: interpersonal processes and primary groups –formal and informal social network and social support systems, including the family, work group and friendship networks.
- Mesosystem: institutional factors –social institutions with organizational characteristics, with formal (and informal) rules and regulations for operation.
- Exosystem: community factors-relationships among organizations, institutions, and informal networks within defined boundaries.
- Macrosystem: public policy – local, state and national laws and policies.
- Chronosystem: This was a later addition by Bronfenbrenner (2004) and was not taken into account by McLeroy et al. This concept "encompasses change or consistency over time not only in the characteristics of the person but also of the environment in which that person lives" (Marentette, 2007).

Now a revised innovation framework is described based on the theoretical framework presented above. The structure includes the implicit assumption that innovation originates

from the human person but is significantly influenced by interaction and interconnection with the five other layers. The revised innovation framework includes a small number of references for the purpose of illustration.

Personal (Individual) Dimension: this layer includes the intrapersonal characteristics that assist or inhibit innovativeness. Development of knowledge, skills and competencies through education and training to support innovation both in terms of creative invention and of implementation are relevant here (Amabile et al., 2003).

Interpersonal: formally this dimension will include the ability to contribute to and direct teams or work groups. Informally it will include social networks, communities of practice and personal contacts, both inside and outside the organization. Interpersonal attributes such as empathy will also be deemed relevant in this layer (Ciborra, 2002).

Organizational: the characteristics of the organization that the person is a member of will be significant for this layer. Culture, climate, and the management of innovation and change will influence the person's tendency to innovate (Goffin & Mitchell, 2005).

Inter-organizational Systems: this layer will include relationship of the organization with peer organizations, academic institutions, state-sponsored support bodies (Etzkowitz & Leydesdorf, 2000). The layer will also encompass formal and informal networks, clusters that support innovation, and the general area of inter-organizational systems (IOS) which is having increasing influence on business to business (B2B) and business to government relationships.

Socio-economic: this dimension will include innovation policy of local, regional, state and supra-national (for example the European Union), National Systems of Innovation (NSI) (Lundvall, 1995), indicators of innovation (OECD, 2005) and important economic theories of innovation (Schumpeter, 1934).

Chronological Generations: Analogous to human development, "generations" can encompass a number of concepts. At a macro level it will take cognizance of the time dimension of the innovation environment which has been ,for example, outlined in Rothwell's (1994) taxonomy of innovation processes. At the organizational level this would involve assessing the innovation maturity level such as the "archetypes" of innovation proposed by Tidd et al. (2005). In the realm of information systems Ward et al. (1990) developed a three era model of IS to illustrate this concept.

Now that we have outlined the background of the paper and the theoretical framework we will proceed to present the case study and the research methodology.

3 CASE STUDY

The case study was based in APC Ireland, a subsidiary of the American Power Conversion (APC) Corporation. The Corporation entered a major period of transition in the first quarter of 2007 with completion of its acquisition by Schneider Electric. APC designs, manufactures and markets back-up products and services that protect hardware and data from power disturbances. The explosive growth of the Internet has resulted in the company broadening its product offerings from uninterruptible power supplies (UPS) to the high-end InfraStruXure ™ architecture in order to meet the critical availability requirements of internet service providers (ISP) and data-centres. This modular design integrates power, cooling, rack, management and services, which allows customers to select standardised modular components using a web-based configuration tool. The Corporation reported sales of $2 billion in 2005, globally employs approximately seven thousand people and is a Fortune 1000 company. However,

recent financial reports have stressed that the company needs to implement significant improvements in manufacturing and the supply chain (Results APCC 2006). According to these reports, the company must work to develop a “lean, customer-centric, ambidextrous organisation” in order to reach “optimal efficiencies in our processes”. APC has two locations in the West of Ireland that serve the European, Middle East and Africa (EMEA) region. The Manufacturing Operations site, based in Castlebar, employed approximately 100 people while a number of functions including sales, information technology, business support and research and development (R&D) are situated in Galway with a workforce of approximately 300. Responding to the supply chain challenge, a Lean Transformation project was set-up in the Castlebar campus in February 2006 with a cross-functional team of twelve members drawn from Management, Engineering, Manufacturing, Materials Planning, Quality, and Logistics functions. The primary management information system employed by APC is Lotus Notes, a collaborative software system that manages its knowledge flows. It provides a tightly controlled environment for asynchronous group work; where collaborators can have different or independent work patterns. The strength of the MIS function in APC was viewed as an important advantage by Schneider in their acquisition analysis and APC’s “intimacy with information technology” was identified as central to the creation of synergies with Schneider’s power solutions subsidiary MGE.

4 RESEARCH APPROACH

The conclusions by Benbasat & Zmud (1999) concerning the lack of relevance in IS research was, to put it mildly, a criticism of the discipline. Consequently the initial approach to the case study was closely related to the following recommendation in their paper:

> IS researchers should look to practice to identify research topics and look to the IS literature only after a commitment has been made to a specific topic.

Furthermore, Mårtensson & Lee (2004) have proposed that dialogical action research can help “resolve the rigor-relevance dilemma” which has bedevilled research in IS and in the wider context of business and social sciences. The research design followed the advice of Benbasat & Zmud that firstly there was a need to spend time in the organization, observing and listening, in order to get a feel for the situation. Data collection methods during this phase involved: maintaining a log book, reviewing documents and information systems, records, interviews, observations (direct and participant), artefacts and surveys in order to develop a database and body of evidence (Gillham, 2002; Yin, 1994). A total of 29 unstructured or open interviews were undertaken that involved approximately 60 hours of interview time and 24 days spent in the company sites. The interviews were conducted across a wide area of the organization that included: Senior Managers with global, EMEA, and site responsibilities, Middle-Managers, Team Leaders, Engineers and a number of people in general planning roles. The main contact point during the diagnosis phase was the Plant Manager of the Castlebar location which involved approximately eleven direct meetings with an estimated seventeen hours of interaction.

There was agreement in January 2007 to move forward using dialogical Action Research with meetings every two weeks in Castlebar. Here is a brief description of this approach:

> In dialogical action research, the scientific researcher does not "speak science" or otherwise attempt to teach scientific theory to the real-world practitioner, but instead attempts to

> speak the language of the practitioner and accepts him as the expert on his organization and its problems.

The meetings during this phase resulted in over 20 hours of recorded interactions translating into almost 60,000 words of transcripts. In particular, the discipline of having to take regular timeout in a "time-pressured" manufacturing environment was a major incentive for the Plant Manager to agree to this approach. However the realities of the situation have resulted in a further adaptation of Mårtensson & Lee's methodology: the research "timeout" for reflective one-to-one dialogues consisted of finding a quiet place in the building and away from the office. The Plant Manager also considered the framework advantageous since it allowed him to retain control and responsibility for all decisions, implementations and communications. However there are a number of practical risks to this type of longitudinal research in a dynamic changing corporate environment, such as the realities of reorganisations and relocations that are not pointed by Mårtensson & Lee. Furthermore, in order to address the subject of rigour we adopted the five principles proposed by Davison *et al.* (2004) to evaluate the research: the Principle of the Researcher–Client Agreement (RCA), the Principle of the Cyclical Process Model (CPM), the Principle of Theory, the Principle of Change through Action, and the Principle of Learning through Reflection.

We will proceed to analyse the case study using the lens of ecological systems theory which we outlined above.

5 ANALYSIS AND DISCUSSION

The purpose of this section is to evaluate the project using the framework of ecological systems theory which is the main theme of this study. The idea here was to assist the practitioner to reflect on the project starting with the inner layer of the individual and moving through the organisational perspective out to the socio-economic and chronological dimensions. This encompasses the six layers of the ecological typology introduced earlier.

Personal Dimension: The subject of the dialogical action research was the plant manager who changed from his initial role as engineering manager at the beginning of the project. This is an important point as ecological systems theory emphasizes the importance of role as a personal attribute with Bronfenbrenner (1979) even making the point that a role can take on almost "magical" qualities. By his own admission the plant manager at the beginning of the project would have found "innovation" to be a very fuzzy concept. Everybody considered it to be extremely important but it was hard to pin down exactly. The subsequent development of the innovation "Dolmen" helped him to put some structure on the concept and to influence his staff on the importance of the topic.

Interpersonal (microsystem): This layer specifically encompasses the Castlebar and Galway microsystem. By its nature the role of the plant manager had significant impact in the location due to his sphere of influence and his ability to contribute to multiple teams or to direct various work groups. The Plant Manager had championed the Lean initiative in the previous year and the innovation project had emerged from this. However he admitted that he could have done more to publicise the project among his senior management colleagues.

Organisational (mesosystem): The characteristics of the wider APC supply chain organisation needed major changes. This was stated in the company quarterly reports which called for the adoption of lean and customer-centric practices. The organisation would have seen itself as not being innovative in that area. The innovation project was a response to this impetus as an attempt to change the culture and climate and to encourage a general tendency

to innovate. However, the acquisition by Schneider Electric changed the situation again and in particular the adoption of the short interval management (SIM) process was particularly significant for both the microsystem (Castlebar plant itself) and for the collection of microsystems that made up the mesosystem. In this context the mesosystem can be regarded as the multiple work groups that members of the plant belong to in the local and wider MNC context. As pointed out previously, the role of the plant manager would have influence in these contexts. However as we have seen in the analysis of the dialogues, the plant manager recognised that he could have done more to publicise the project among his peers in order to get cross-functional support for the undertaking.

Inter-organizational Systems (exosystem): The exosystem is characterized by the relationship to events which influence the Castlebar plant but to which the Plant Manager is not part of. The acquisition of APC by a very large corporation meant that this layer became more complex and would be influenced by corporate decisions that were outside the control of the plant manager. The relationship of the organization with peer organizations, academic institutions, state-sponsored support bodies increased as the innovation project was undertaken.

The macrosystem is the "most distal and expansive region of the environment" (p 149). The innovation project began when there was increasing emphasis in the building of an innovation economy in Ireland and other regions. An important part of the macrosystem is the FDI strategy of Ireland's industrial development authority (IDA). High Technology Manufacturing is one of the three pillars but the manufacturing in the Castlebar facility was mainly low technology except for the testing process which required expertise in high voltage electricity. However the sister Galway plant has expertise and operations that fall into both the Global Services pillar and the RD& I pillar.

Chronological Generations (chronosystem): The research is situated in a "time" where the role of ICT is having a major influence on the shaping of organisations and their interaction. This was particularly seen in the organisation of the APC supply chains, parts of which were being outsourced to global players in the logistics industry.

Technological Capability: This was introduced into the ecological system as it was deemed necessary for the understanding of a case study in a high technology company. At the personal layer the main technologies used in the Castlebar facility were automatic insertion and soldering equipment together with high voltage test facilities. All support personnel had access to an Oracle enterprise resource planning (ERP) system while the customer relationship management (CRM) was run on Siebel software for those who required it. Furthermore the management information system available to personnel was built on IBM's Lotus software and contained extensive bespoke database applications. An intranet was available to those who had personal computers as part of their job while a number of workstations were made available to operators who did not have their own PCs. The hardware and software for APC's InfraStruXureTM product line was sophisticated in that it was designed to meet the availability and reliability requirements of high-end IT systems and networks. The Schneider Electric Corporation is a high technology company with over 90,000 employees that provides power and control solutions to the residential, building, industry and energy infrastructure markets.

The ecological landscape of the dialogical action research project is captured in the figure below.

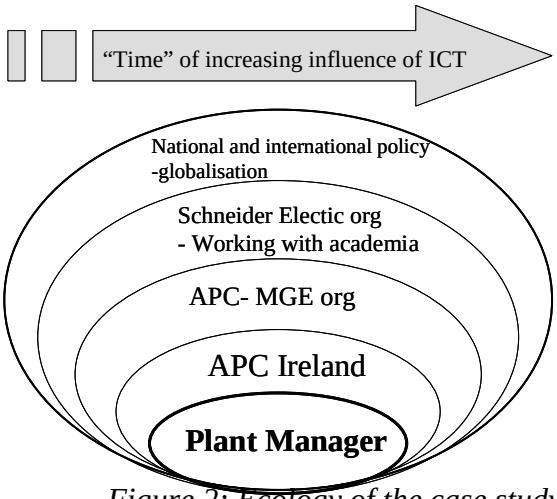

Figure 2: Ecology of the case study

Now we will present the conclusions of the study and some suggestions for future work.

6 CONCLUSIONS

This paper has argued that ecological systems theory is a novel and illuminating lens in which to view information systems innovation. The work is a response to the assessment by IS scholars that there are significant research questions to be addressed in this important topic. The result is an adaptation of Urie Bronfenbrenner's ecological systems theory (EST) in order to apply it to the IS and innovation landscape. This lens, we argue, is an important theoretical contribution because it provides a fresh perspective for academic researchers to investigate the phenomenon; and it offers an accessible conceptual structure to navigate the increasingly complex innovation ecosystem. A case study was presented that included the testing of a new form of action research recently proposed to the IS community by Mårtensson & Lee.

The key findings included:

- Innovation is a complex subject that is increasingly seen to be crucial to an organisation's success and even survival. However after many years of investigation, the contribution to theory is still being questioned and found wanting by many researchers in the area.
- The topic is relatively unexplored in the information systems field and there has been calls for a more radical approach to stimulate research and debate among the IS community.
- An adaptation of ecological systems theory is proposed in order to address the gaps identified in the review of the literature. The tailored theory, which is the basic argument of this paper, includes the dimension of technology and a greater emphasis on the relational aspect of the ecology. Furthermore it is argued that the new theoretical framework can provide an impetus for research in the area.
- The literature is unanimous in claiming that the topic of innovation is very complex. Ecological systems theory has the breath, depth and a proven track record to accommodate complexity.
- The dialogical AR provided an *interpretive space* for the practitioner. The importance of this factor for innovation has been emphasised by Lester and Piore (2004) to compliment the *analysis* dimension of innovation.

Future work is required to verify the EST approach in other situations and to further develop the technological component of the model.

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