OPAALS PROJECT

Contract n° IST-034824

WP11: Bridging Digital Ecosystems Research to Regional Development and Innovation in the Knowledge Economy

D11.2 – Social and Spatial Structures of Collaboration and Knowledge Flow that Underpin Innovation among SMEs in Biotech and Digital Media

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Short Description: This deliverable reports on the results of task 11.1. This involves an investigation of the socio-spatial structures of collaboration and knowledge flow among SMEs in the biotechnology and digital media sectors in Ireland. The study was guided by a case-study research design. The cases take the form of "innovation biographies", tracing back the history/genealogy of particular innovation trajectories. Eight cases were investigated of which six are reported. The analysis informs the requirements and possible uses of a future digital ecosystem.

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Achievements*	All planned activities for task 11.1 were carried out. Instead of four case studies, we conducted eight case studies, of which six are reported in this deliverable
Work Packages	Extensive contribution to WP 11. WP11 focuses on bridging Digital Ecosystems Research to Regional Development and Innovation in the Knowledge Economy. As outlined in D11.1, the objective was to bridge the theoretical deliberations surrounding the Digital ecosystems concept with the practical concerns of regional development policy. Towards this, D11.2 reports on research that investigated the socio-spatial foundations of knowledge flow and innovation. The research provides critical insights into the innovation processes within and between companies and the spatial configuration of these processes, notably the extent to which these processes are regionally bounded. The selected case-study industries (biotech and digital media) are generally identified as core sectors for regional economic growth in the knowledge economy and are dominated by SMEs. The Deliverable identifies important implications for the structure and possible functions of Digital Ecosystems in these two sectors (and sectors characterised by similar knowledge bases). In addition, the insights can benefit WP12. Notably Deliverable 12.11 which looked at open innovation models and the role of ecoystems in sharing knowledge and information.
Partners	All partners will benefit from reading this deliverable
Domains	Social Science is the core scientific domain involved in this deliverables. The lit review and material covers various more specific fields, notably innovation studies, spatial economics economic geography and economic sociology.
Targets	The principle targets of this deliverable include the OPAALS community, other research communities concerned with digital ecosystems, regional development agencies and authorities, industrial associations, associations of SMEs and the various academic communities of the disciplines mentioned above.

Publications*	No elements of this research were published at the time of reporting. But the authors have been invited to contribute one book chapter and plan to submit peer reviewed journal articles drawing on the material contained in this report
PhD Students*	No PhD students were involved.
Outstanding features*	The current understanding of the social and spatial foundations of innovation processes is limited. This deliverable provides an important contribution to this understanding and therefore to the possible applications of digital ecosystems. In particular the deliverable develops the concepts of the digital ecosystem as a new type of 'public space' facilitating both intentional and unintentional knowledge flow (or 'buzz').
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The information marked with an asterisk (*) is provided in order to address Recommendation n. 4 from the Year 2 review report

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EXECUTIVE SUMMARY

Deliverable 11.2 reports the results of Task 11.1 of the second phase of the OPAALS Project. Task 11.1 is part of WP11, that focuses on bridging the divide between Digital Ecosystems research and regional development and innovation in the knowledge economy. The objective of WP11 was to bring together the theoretical deliberations surrounding the Digital ecosystems concept and the practical concerns of regional development policy.

Digital Ecosystems provide structures of communication and collaboration that can facilitate collective learning, knowledge flow and innovation across SMEs and other actors. In order to understand sustainable digital ecosystems of SMEs and the contribution they could make to competitiveness of SMEs and regional development, we need to understand in depth the processes of knowledge flow and innovation.

As outlined in D11.1, Task 11.1 sets out to explore and explain the social and spatial structures of knowledge flow and innovation among SMEs. The premise of the research is that there are varying pathways to successful innovation and that the social and spatial structures underlying these pathways vary by industrial sector. The study explores these ideas through a series of case-studies of innovation projects in two industrial sectors in the Irish economy, biotechnology and digital media. The two sectors are generally identified as core sectors for regional economic growth in the knowledge economy and are dominated by SMEs. This makes them particularly suitable for Digital Ecosystems research.

The study is guided by a case-study research design. The cases take the form of "innovation biographies", tracing the history/genealogy of particular innovation projects. Eight cases were investigated, of which six are reported.

The case studies of the biotechnology and digital media industry suggest that, the innovation projects of companies in the Dublin area involve very little collaboration with other regional and even national actors. As regards the sources of knowledge during the various stages of the innovation trajectories, the study reveals important differences between the two industries. As regards the intentionality of the knowledge flow, in the biotechnology projects the most vital knowledge is exchanged intentionally. Unintentional knowledge flow appears to have been of limited relevance for the specific innovation trajectories although it does occur and can play a role, particularly during the first stages when most projects tend to be in the hands of academic research groups. In the animation projects unintentional knowledge flow and buzz tends to be more common and relevant. It is most relevant for know-who type knowledge.

The findings suggest that the conceptualisation of 'global pipelines' versus 'local buzz' (Bathelt et al., 2004) is problematic in capturing the knowledge flows. The case studies of the innovation trajectories in the biotechnology and animation industry show that global buzz and virtual buzz was actually more important than local buzz. This is not to say that there is no Irish community and that this community is irrelevant for facilitating intentional and unintentional information flow. However, the

community tends to meet during the international events, rather then locally – local communities are 'buzzing globally' rather than locally.

The case studies suggest that partner choice in both industries is relatively insensitive to distance decay. Most of the core external actors are selected irrespective of their location, nearly solely on the basis of the specific knowledge they can contribute to the collaboration and, in case of digital media, on the basis of their price competitiveness. The knowledge flow, innovation and co-ordination between the geographically distanciated partners is partly facilitated by non-geographical dimensions of proximity, notably social proximity.

The study provides important insights in relation to the social-spatial foundations of knowledge flow and innovation, notably with respect to the influence of the modes of knowledge creation, the organisation of knowledge communities, and the organisation of firms and markets.

In broad terms, the case study findings do provide support for the link between modes of knowledge creation and industrial sectors, in line with received theory. The biotechnology cases depend strongly on an analytical knowledge base while the digital media cases are characterised by a symbolic and synthetic knowledge base. In line with Moodysson et al. (2008) the cases studies also support the idea that most activities are in practice comprised of more than one mode of knowledge creation and that different modes of knowledge creation are present in different stages of the innovation trajectory, with different intensities.

As to the link between the type of knowledge base and the geography of knowledge flow and innovation, the case study projects in the biotech industry broadly match the target hypotheses. Most of the stages that are dominated by an analytical mode of knowledge creation involve distant partners. The digital media cases, on the other hand, strongly challenge the target hypothesis. Nearly all of the main partners and clients during the innovation stages dominated by the symbolic mode of knowledge creation are located overseas. There is little evidence for the idea that the need for know-who type knowledge influences company location or that partner choice is influenced by a distance decay in know-who type knowledge.

As regards the organisation of knowledge communities, the 'system of professions' and the boundaries of different occupations is more fungible and less certain in digital media than in biotechnology. Firms in both industries rely heavily on networking with partners to put together the innovations. External networks are a significant source of diversity in knowledge flows – and therefore of heterarchy within firms. However there are also important sources of hierarchy in external networks.

Our research confirms that, although some innovation networks are more open than others, innovation seems to be strongly driven by engagement with public spaces and 'communities' where information sharing is relatively open. Innovation remains rooted in an engagement with a community that involves accessing diverse sources of knowledge through decentralized networks, loosely defined ties, and quasi-public spaces. In both industries, public spaces (Lester and Piore, 2004) are crucial to innovation

As regards the organisation of firms and markets, in each sector, it appears that it is individuals who are the market for the product – whether as patient or as viewer. However, for the companies the markets that matter are those intermediaries that control access to these final users.

The findings have important implications for the structure and possible functions of Digital Ecosystems in the two sectors in the Irish context (as well as sectors characterised by similar knowledge bases).

In the Irish biotechnology and digital media industries, a digital ecosystem is unlikely to play a significant role in promoting regional development as a project management tool. In the Irish context, a digital ecosystem is more likely to stimulate regional development by acting as a more general communication tool and knowledge resource, connecting all regional players in a specific industry or field (irrespective of whether or not these actors are partners in a specific innovation project). In this way, the digital ecosystem could facilitate a type of open knowledge space.

The open knowledge space and digital ecosystem we envisage would provide strong assistance/support functionality. Companies and individual actors provide information about their knowledge assets and requirements. One of the central questions becomes "what knowledge that could be of value to me do you have and are you willing to share?"

The digital ecosystem should provide a multi-level data/communication structure. Some levels are shared by all firms and individual actors while other levels are only accessible to smaller groups. The different levels mediate knowledge and information with different levels of sensitivity, requiring different levels of social proximity and trust.

The digital business ecosystem should involve the entire social world of the firms, linked to the specific inter-firm networks in which firms participate, as well as to the loose web of ties that people within innovation projects share with others in the industry. In the light of the salience of public spaces and 'communities', rather than merely facilitating knowledge flow and collaboration related to a specific innovation project, a DE becomes a new type of public space, facilitating 'interpretive action'.

This new public space facilitates both intentional knowledge flow and unintentional flow, through 'buzz'. Although local communities do exist in both industries, currently the level of local buzz is limited. A well functioning digital ecosystem would intensify the level of local buzz.

We have shown how processes of knowledge flow and innovation differ significantly from industry to industry. Hence the specifics of a Digital Ecosystem and the precise route via which it can contribute to regional development will also differ across industries. The research points to the importance of awareness of the range of actors and socio-spatial structures involved in innovation trajectories when developing a Digital Ecosystem. Based on the research findings, this report provides some general suggestions regarding the implications for the biotech and digital media industries in Ireland.

The relevance of these suggestions will need to be validated in future research (including OPAALS phase III), notably interviews with key-industry players and experts. In addition, future research can expand our knowledge regarding the use and structure of Digital Ecosystems by changing the unit of analysis from projects to firms and individuals. Firms occasionally collaborate with local partners and, over time, these collaborations give rise to local networks. In addition, local communities do exist. Social network analysis (with the firm and/or the individual as the unit of analysis) can provide valuable additional insights into the structure of these networks/communities and the related knowledge flows and can provide additional ideas regarding the application of Digital Ecosystems as local knowledge resources. In addition, social network analysis can provide an important tool for identifying potential catalysts in the development of the digital ecosystems.

1 INTRODUCTION

This Deliverable reports the results of Task 11.1 of the second phase of the OPAALS Project. Task 11.1 is part of WP11, which focuses on bridging the gap between Digital Ecosystems research and Regional Development and Innovation in the Knowledge Economy. The objective of WP11 was to bring together the theoretical deliberations surrounding the Digital ecosystems concept and the practical concerns of regional development policy.

A Digital Ecosystem (DE) is a self-organising digital infrastructure established with the aim of creating a digital environment for networked organizations which is capable of supporting co-operation, knowledge sharing, the development of open and adaptive technologies and evolutionary business models (Nachira et al., 2007). Digital Ecosystems provide structures of communication and collaboration that can facilitate collective learning, knowledge flow and innovation across SMEs and other actors.

The DE and its uses fits well with recent work in studies of innovation which emphasis the collective, collaborative processes that underlie innovation. This research details how innovation processes are becoming increasingly complex, involving different types of knowledge. Individual firms can no longer rely on their internal sources of knowledge alone. Instead additional knowledge needs to be accessed from external sources. These trends have been characterised as a transition towards ‘open innovation’ (Chesbrough, 2003) and ‘distributed knowledge networks’ (Asheim, Boschma and Cooke, 2007)

In order to understand sustainable digital ecosystems of SMEs and the contribution they could make to competitiveness of SMEs and regional development, we need to understand in depth the processes of knowledge flow and innovation. As outlined in Deliverable 11.1, Task 11.1 set out to explore and explain the social and spatial structures of knowledge flow and innovation among SMEs. The premise of the research is that there are varying pathways to successful innovation and that the social and spatial structures underlying these pathways vary by industrial sector. The study explores these ideas through a series of case-studies of innovation projects in two industrial sectors in the Irish economy, biotechnology and digital media. These take the form of “innovation biographies”, tracing back the history/genealogy of particular innovation projects. Such a qualitative micro-studies approach is novel and certainly unconventional. An analysis of topics studied in the EU Framework programs concludes that "what was most striking was that hardly any projects focused on innovation processes in firms. Given the importance of innovation for economic and social change, and the role of firms in innovation, this must be seen as a glaring omission” (quoted in Fagerberg 2006, p. 21).

The study collected and analysed detailed material on eight case studies. Only six of the case studies are included in this deliverable but the material of all eight case studies is integrated in the discussion. A total of 43 interviews were conducted with staff and individuals involved in the eight innovation projects, as well as industry experts. All interviews were recorded, transcribed and coded for analysis. Interview

data were supplemented and triangulated with information from secondary sources, notably annual reports, journals and Internet sites.

Section two of this deliverable report presents the theories and themes on which the study focuses. This is followed by the research design and methodology in section three. Section four introduces the biotechnology and digital media sectors in Ireland. Next, section five discusses the case study findings and the implications for theory. After this, the implications of the findings for digital ecosystems and the OPAALS project's objectives are presented in a dedicated section (section 6). Six of the eight detailed cases studies are included at the back of the report. All case studies have a similar structure, broadly in line with the structure of the theoretical framework and the discussion in section five. They begin with an overview of the innovation project. This is followed by a description of the patterns of knowledge flows and innovation (the actors and their location; the sources of knowledge; the way in which partners are identified; the mode of knowledge exchange and proximity and the importance of the region). The next four sections provide material on a number of broad factors that may shape the patterns of knowledge flow and innovation: the underlying knowledge base; the central occupational group and knowledge communities; the organisation of firms and markets; and the institutional context.

At this point we would like to thank all the people at the various firms and institutions who have co-operated with this research. In particular, we would like to thank Maria Ginnity and Mark Faherty of Forfas, for supporting and facilitating this research. In addition we specifically thank Dr. Jim Ryan (The Circa Group), and Dave McConnell (Trinity College Dublin) for the constant flow of sector-specific knowledge and for introducing us to the companies.

2 THEORETICAL FRAMEWORK

In order to understand sustainable digital ecosystems of SMEs and the contribution they could make to competitiveness of SMEs and regional development, we need to understand in depth the processes of knowledge flow and innovation.

We see innovation as the outcome of a variety of socio-spatial processes that shape which kinds of innovation take place, when and where they take place, what ownership forms are associated with them and how the innovation process itself mobilizes different alliances and networks of actors and institutions. There is now a large body of literature and theory that deals with various aspects or themes of the socio-spatial structures of knowledge flow and innovation. The research for task 11.1 focuses on a select number of theories that are deemed to be particularly revenant in the context of digital ecosystems. The next section outlines the current thinking in relation to the socio-spatial structures of knowledge flow and innovation. This is followed by a discussion of a set of sectoral characteristics or factors that are shaping the structures and patterns of innovation and knowledge flow: the knowledge base; central occupational group and organisation of knowledge communities; the organisation of firms/market and institutional context

2.1 Socio-spatial Structures of Knowledge Flow and Innovation

Research on innovation has typically placed the firm at the centre of the innovation process – although this has been challenged in recent times through discussions of networked firms, regional innovation networks (Saxenian, 1994 and 2006) and systems of innovation (Lundvall (1992). It remains crucial to understand firm strategies for innovation and to analyse how firms organise themselves and mobilise elements in their environments (ecosystems) to engage in innovation (Amin and Cohendet, 2004). These can take a variety of forms that differ in highly significant ways. Lorenz and Valeyre (2006) for example, find that a variety of forms of organisational learning and innovation exist – lean and learning models emerge alongside existing models of Taylorist and direct control within firms. They find that these models of firm learning are systematically related to different patterns of innovation, patenting and other outcomes as well as to different sectoral and national institutions. Recent studies of firms have therefore become concerned with how firms forge interdependencies (traded/ formal and untraded/informal) with other firms in their ecosystem, how firm strategies are themselves shaped by the dynamics of these inter-firm networks and how firms negotiate the rewards from innovation (Storper, 1997).

In addition, researchers are increasingly looking beyond firms and inter-firm networks to non-firm processes such as interpersonal networks, associations and public and other collective organisations (Saxenian, 2004) which are an important part of the broader worlds of production

Some authors emphasise inter-personal ties and, in particular, the 'knowledge communities' that consist of person to person networks operating below and across the level of inter-firm networks. There are in fact classic studies, now somewhat neglected, of the intersection, or lack of intersection, between firm ties and worker ties – research that asks to what extent worker networks cut across firm boundaries, to what extent they are contained within them, and to what extent worker relations across firms are mediated through gatekeepers that become 'entry points' into the networks within firms (Allen and Cooney, 1974). Research has also looked more closely at the form of organisation of these communities and networks beyond the firm, recognising that the structure of networks – and knowledge flows within them – will vary significantly according to whether the workers are organised through 'techie' networks, professionalized occupations, crafts, scientific disciplines, communities of practice (Lave and Wenger, 1991), epistemic communities (Haas, 1992) and so on.

But firms are also embedded within a different set of networks – the network of formal and semi-formal associations that are part of any sector and ecosystem. These can act as resources but also shape the innovation process. They include universities; public economic and industrial development agencies (Ó Riain, 2004; Block, 2008); professional, trade and industry associations; and commercial supporting firms (Saxenian, 1994). Research examines what role these different institutions play in each innovation coalition; what flows of information move between these institutions and the innovation coalition to which they are connected; how they facilitate (or don't facilitate) the movement of knowledge across and between innovation coalitions; how they promote new forms of knowledge or priorities within innovation coalitions.

All of these different institutions are seen as important in the regional economies literature, and particularly in the research on high tech regions (e.g. Saxenian, 1994 on Silicon Valley). Their interactions with one another can come to form a kind of 'public space' within which innovation and learning can occur (Lester and Piore, 2006).

Analysts have emphasised for some time that learning and innovation by firms occur within a broader 'system of innovation' – the network of inter-firm relations, public institutions, occupational communities and other actors that surround any firm. Typically, the emphasis has been on how these systems of innovation differ between nations (Lundval et al., 2002; Kim and Nelson, 2000)

A new body of research has demonstrated the importance of 'sectoral systems of innovation' in shaping innovation and growth, particularly in a 'knowledge economy' (Lundvall et al, 2002; Kim and Nelson, 2000; Malerba, 2003). Much technological learning occurs around specific products (Storper, 1997) and this 'product based technological learning' becomes the basis of sectoral systems. The key products within a sector become the focus of learning among a diverse group of economic actors – firms, workers, academics, research policy makers and others. These become crucial constitutive elements of 'business ecosystems', facilitating and shaping knowledge flows.

Sectoral and national systems of innovation interact and potentially complement each other – Michael Porter's famous 'clusters' are one attempt to explain economic

growth through a focus on how sectoral and national institutions interlock to create virtuous circles of industrial development (see also Hollingsworth, 1994; Kitschelt, 1991).

Innovation is increasingly seen as emerging not only from the development and commercial application of science but from a set of frameworks of economic activity or 'worlds of production' (Storper, 1997. The learning economy consists not simply of one model of learning and innovation but of a set of different but coherent worlds of production. There is no single model of growth. Instead there are many diverse frameworks in different industries, regions and countries, each with their own dynamic of learning and innovation. The worlds of production and innovation involve many actors - firm and non-firm, public and private, and more (Storper, 1997; Lundvall et al, 2002).

Increasingly researchers have sought to link the structural dimensions of innovation systems to the form that learning takes within the innovation process – including the importance of different modes of learning such as analysis and interpretation (Lester and Piore, 2006); the dynamic and path-dependent character of that learning across the innovation process (Powell et al 2005), and the negotiation of the meaning of innovation itself (Girard and Stark, 2002; Lester and Piore, 2006).

Learning and innovation in the knowledge economy can take a variety of forms (Lorenz and Lundvall, 2006; Lester and Piore, 2006). This variety of potential pathways to innovation and the social structures that sustain those pathways need to be examined.

Clearly, the social aspects of innovation are crucially embedded in the spatial organisation of knowledge flow and innovation. This has important implications for regional development processes and policy. In relation to this, since the mid-1980s territorial concepts such as spatial clustering, agglomeration, industrial district and national/regional system of innovation have attracted much interest from academics and policy-makers concerned with regional/national economic development. Indeed, innovative clusters have become a policy panacea for many governments and international agencies such as the OECD that see clusters as drivers for regional and national competitiveness and growth.

Several cluster advantages may underlie this enhanced competitiveness. One part of the academic literature has focussed on traditional agglomeration economies, notably the external economies of scale and efficiencies in the supply of inputs, services and the labour market. However, empirical research does not always find evidence for extensive local production linkages between firms in a sector, thereby undermining at least part of the argument. Another stream of the cluster literature has focussed on the knowledge flows and knowledge spillovers between local actors that are believed to support the process of localised learning and innovation. Contributions to a knowledge-based theory of spatial clustering typically interpret learning and innovation as interactive processes that involve an exchange of knowledge between firms and other actors (including universities and other research institutions). The idea is that proximity in local clusters can lead to dense networks of communication and information linkages that support both intentional and unintentional knowledge flows.

Although remaining highly influential, these ideas are increasingly challenged by empirical studies that show that firms in even the most developed clusters are often highly depended on non-local relations for their knowledge. Recent contributions to the knowledge-based theory of spatial clustering specifically incorporate the idea that firms in clusters depend on both local and non-local knowledge flows through 'local buzz' and 'global pipelines' (Bathelt *et al*., 2004; Gertler and Wolfe, 2006). Global pipelines enable local firms to overcome shortcomings in local knowledge by linking firms with important developments generated by non-local actors. This constitutes a move to a more complex view of a multi-scalar geography of knowledge and local clusters as nodes in global networks.

Notwithstanding the importance of these contributions we still have a very limited understanding of the relative importance of local and global knowledge flows in knowledge creation and innovation and of the extent to which different flows are sensitive to proximity. A better understanding is facilitated by distinguishing between different dimensions of proximity, different modes of knowledge exchange and different levels of intentionality of knowledge exchange.

As regards the dimensions, besides geographical proximity, there are several other dimensions of proximity (Torre and Gilly, 2000; Torre & Rallet 2005; Boschma 2005, Moodysson, 2007). Boschma (2005) applies a very comprehensive categorisation involving cognitive, organisational, social, institutional and geographical proximity. All these forms of proximity can facilitate interactive learning and innovation. Geographical proximity may facilitate knowledge flow but it is not a sufficient condition because knowledge flow and learning require at least cognitive proximity and in most cases a combination of dimensions is at play. Neither is geographical proximity a necessary condition because the non-geographical forms of proximity can act as substitutes for geographical proximity (see also Gertler, 2008). The conceptualisation is complicated by the acknowledgement that geographical proximity may play a role in strengthening social, organisational, cognitive and institutional proximity (Boschma, 2005).

As regards modes of knowledge exchange, knowledge can be exchanged using different modes or media, including face-to-face, post, telephone, email, video-conferencing, internet and intranet forums and digital ecosystems. The requirement of face-to-face communication tends to be related to geographical proximity of actors. However, innovations in communication technology, in conjunction with an increase in organisational proximity, have reduced the need for face-to-face contact in the exchange of knowledge, even in the context of detailed technical design issues (Mckinnon 1997; Torre & Rallet 2005; Van Egeraat and Jacobson, 2006). In addition, the face-to-face contact that is required is often only required for short periods and can often be satisfied via frequent long-distance travel and the seconding of research staff for extended periods of time (Van Egeraat and Jacobson, 2006, Arita and McCann, 2000). This has been referred to as "temporary geographical proximity" (Torre & Rallet. 2005) but this may provide more confusion than clarity – it is simply face-to-face contact between geographically distant partners.

As regards intentionality, some knowledge flows are intentional while others are unintentional. Unintentional interaction (Oerlemans and Meeus, 2005) within a group of actors involves the acts of observation and comparison (Malmberg and Maskell,

2002). The unintentional knowledge flows and knowledge spillovers are believed to be particularly sensitive to proximity, both geographical and non-geographical. Social, cultural and institutional proximity are particularly important for unintentional knowledge flow. Geographical proximity is important because much (though not all) unintentional knowledge flow takes place during face-to-face events and because the non-geographical forms of proximity are augmented by geographical proximity.

The distinction between intentional and unintentional knowledge flow is closely related to the concept of "buzz" that is rapidly gaining popularity (Bathelt *et al*., 2004; Storper and Venables, 2004; Gertler and Wolfe, 2006; Gertler, 2008; Moodysson, 2008). Asheim et al. (2006) argue that buzz has been defined in rather ambiguous ways and call for a more precise definition, distinguishing between buzz and face-to-face communication. As such they present it as a different mode of communication and knowledge exchange. This is slightly problematic since the authors make the point that buzz is more efficiently transmitted in face-to-face contexts, thereby creating an overlap between the categories of modes of communication. Buzz and face-to-face are distinguished on various grounds but one of the main and clearest differentiating factor involves the level of intentionality of the flow. "Buzz refers to non-deliberate knowledge and information exchange propensities" (p.214) and "is predominantly about knowledge spillovers (p. 216).

The dimensions of geographical proximity, modes of knowledge exchange and levels of intentionality are clearly integrated concepts that can assist the analysis of spatial structures of knowledge flow and innovation.

When analysing knowledge flow and its relation with geographical proximity between partners it is important to realise that that important amounts of knowledge do not flow directly between actors. For example, actors in the biotech industry source great amount of knowledge from journal articles. It is therefore helpful, as we did in our case studies, to distinguish between the collaborative actors and sources of knowledge, and consider their geography separately. Although there is great overlap, this overlap is far from total.

2.2 Sectoral Factors

The premise of the research is that there are varying pathways to successful innovation and that the socio-spatial structures underlying these pathways vary by industrial sector. These differences are the outcome of numerous technological, economic and social factors. The current research project focuses on the influence of a select number of these factors. These are here discussed under three, partly overlapping, headings: type of knowledge; central occupational group and knowledge communities; organisation of firms and markets.

2.2.1 Knowledge Base

To understand the social and spatial pattern of knowledge flows and innovation we need to be sensitive for the type of knowledge involved. In this regard an established distinction is that between codified and tacit knowledge (Polanyi, 1967). Recently Asheim and Gertler (2005) have criticized this binary classification for a narrow understanding of knowledge and innovation. This led to a conceptualisation of

different types of 'knowledge bases' that are used in innovation processes. A distinction is made between 'synthetic', 'analytical' and 'symbolic' knowledge bases (Asheim, Boschma and Cooke, 2007; Asheim, Coenen and Vang, 2006). This distinction takes account of the rationale for knowledge creation, the criteria for successful outcomes, the strategies of turning knowledge into innovation and the interplay between the actors involved. The categories entail different mixes of tacit and codified knowledge, qualifications and skills required by organisations, as well as specific innovation challenges and pressures. The typology encompasses the diversity of professional and occupational groups. The sections below identify the main characteristics of the three knowledge bases as identified by the proponents of the conceptualisation.[1]

An analytical knowledge base refers to activities where scientific knowledge based on formal models and codification is highly important. Biotechnology and nanotechnology are identified as typical examples. Knowledge inputs and outputs are often about developing new knowledge about natural systems by applying scientific laws – 'know-why'. Although the knowledge is often codified, tacit knowledge is not irrelevant since innovation always involves both types of knowledge. University-industry links and networks are relatively important. The activities require specific qualifications. In particular analytical skills, abstraction and theory building are often needed. The core of the workforce often needs some research experience or university training. Knowledge creation in the form of scientific discoveries and generic technological inventions is relatively important and often lead to patenting and licensing activity. Knowledge application is in the form of new products and processes and innovations tend to be relatively radical. An important route of knowledge application is new firms and spin-off companies based on radically new inventions or products.

A synthetic knowledge base refers to activities where innovation takes place mainly through the application or novel combinations of existing knowledge. Often this occurs in response to the need to solve specific problems identified during the interaction with customers and suppliers. Plant engineering and shipbuilding are proposed as industry examples. Products are often one-off or produced in small series. R&D, especially the research element, is generally less important than in the analytical knowledge base. If relevant it often takes the form of applied research, but more often it is in the form of product or process development. University-industry links are sometimes relevant but clearly more in the field of applied research and development. Knowledge is often created in an inductive process of testing, experimentation, computer-based simulation or through practical work. Knowledge output can be partially codified but tacit knowledge is more prevalent than in the analytical knowledge base, in particular due to the fact that knowledge often results from experience gained at the workplace and through learning by doing. There is a relatively high requirement of concrete 'know-how' and practical skills often provided by polytechnical schools and on-the-job training. Innovation tends to be an incremental process, dominated by the modification of existing products or processes. Most innovation takes place in existing firms while spin-offs are relatively less frequent.

[1] The following paragraphs draw on Asheim, Boschma and Cooke (2008), Asheim, Coenen and Vang (2006) and Gertler (2008)

The proponents relate symbolic knowledge to the aesthetic attributes of products, to the creation of designs and images and the economic use of various forms of cultural artefacts. This type of knowledge is considered particularly relevant to 'cultural industries' such as media, publishing, advertising, design or fashion. An important part of the innovation in these industries takes the form of the 'creation' of new ideas and images, rather than new physical production processes. Symbolic knowledge may be embedded in tangible goods but its economic value arises from its intangible character. In the cultural industries in particular the input is aesthetic rather than cognitive in quality. The knowledge involved is incorporated and transmitted in aesthetic symbols, images, and narratives with strong semiotic knowledge content. This type of knowledge is often narrowly tied to a deep understanding of the habits and norms and 'everyday culture' of specific social groupings. Due to the cultural embeddedness of interpretations this type of knowledge base is characterized by a distinctive tacit component and is often highly context-specific. The acquisition of skills is less tied to formal qualifications and university degrees than to practice in various stages of the creative process. The process of socialisation (rather than formal education) in the trade is not only important with regard to training 'know-how', but also for acquiring 'know-who', that is knowledge of potential collaborators.

The knowledge base conceptualisation implies that different industries are characterised by different social-spatial conditions and pathways to innovation. In relation to space, the proponents suggest that the different knowledge bases are characterised by different sensitivities to geographical distance for knowledge flow (Asheim, Coenen and Vang, 2006; Gertler, 2008). Industries drawing on the analytical knowledge base rely heavily on codified knowledge that tends to be publicly available. As a result face-to-face is believed to be of less importance in the process of accessing scientific knowledge. At the same time, companies in this industry are believed to cluster near major universities partly to gain access to world leading researchers. Industries drawing on a synthetic knowledge base are more sensitive to geographical distance. Face-to-face communication is of greater importance due to the importance of customised solutions and the partly tacit nature of the know-how involved. Industries drawing on the symbolic knowledge base are believed to be most sensitive to geographical distance in relation to knowledge exchange. 'Know-who' type of knowledge is augmented through large gatherings which require face-to-face contacts. In addition, the craft-production nature of the innovation process and the tacit nature of the know-how call for a high amount of face-to-face communication.

The proponents stress that the threefold distinction outlined above refers to ideal types and that most activities are in practice comprised of more than one knowledge base. Innovation projects often involve actors from different industries with different knowledge base characteristics. This has been convincingly illustrated by the micro-scale studies conducted by Moodysson *et al*. (2008). Here the focus is the 'mode of knowledge creation' - the characteristics of the actual knowledge creation activities and knowledge interactions - in specific innovation processes, within one particular industry. This allows for a concrete investigation of how the different modes are integrated in concrete innovation projects. The case study findings show that different modes of knowledge creation are present in different phases of innovation processes, but with different intensity, and different outcomes for the spatiality of the knowledge flows. Even at the activity level it is not possible to characterise activities as either

analytical or synthetic. However, in most cases the authors were able to clearly identify a dominant mode of knowledge creation in the different activities. In terms of the space, the findings broadly support the idea that synthetic modes of knowledge creation are relatively more sensitive to proximity effects than analytical modes of knowledge creation but the mix of modes results in "a more fine-grained picture" (*Ibid*. p. 1053).

2.2.2 Central occupational group and the organisation of knowledge communities

The knowledge flows and innovation processes of different industries are shaped by their dominant occupational groups and the way knowledge communities are organised. In sectors where the dominant occupational groups are highly professionalised and have achieved a high degree of social closure around their formal knowledge base, we might expect a more hierarchical organisation of knowledge flows (see also Lester and Piore, 2006). However, more decentralised relations in an open network incorporating multiple professions, occupations and sources of expertise are likely to generate different type of knowledge flows – whether this takes the form of 'heterarchical logics' within firms (Girard and Stark, 2002) or interpretative work in 'public spaces' such as industrial districts or universities (Lester and Piore, 2006). Given the importance of formal science and medicine in biotechnology and the more commercialised world of commercialised developers and technical professionals, with much weaker social closure, in the digital media sectors, we can expect significant variation here.

The form of organisation of knowledge communities is known to vary from sector to sector with important consequences for knowledge flow and innovation processes. In this respect Coenen et al. (2006) have usefully employed the distinction between communities of practice and epistemic communities. Communities of practice (Lave and Wenger, 1991; Brown and Doguid, 1991) can be defined as groups of actors (individuals) involved in a specific task and communicating regularly with each other about this specific task. Epistemic communities (Haas, 1992) are groups of individuals who share a specific set of knowledge but who work independently of each other. These networks are less formal and knowledge flow is not dependent on a common task or job.

2.2.3 Organisation of firms and markets and institutional context

Important differences exist between sectors in terms of the organisation of firms and markets, the size and age profiles of firms, the type of user markets and forms of regulation. Biotechnology is characterised by a combination of very large and very small firms. Although much of the output is used by patients, the main "customers" are high-status medical professionals and healthcare organisations. Product development processes and markets are intensely regulated by national regulatory authorities. In the digital media sector, small and micro-scale enterprises are more prevalent. Popular culture makes up an important segment of the user market. With respect to regulation, there has been a shift away from government regulation and indeed censorship to co-regulation or self-regulation by the media industry. Digital media in Ireland are very loosely regulated - what is often referred to by policy makers as 'light touch regulation'.

All this has important implications for knowledge flow and innovation processes. Oakey's (1995) research in the UK is still helpful here. In a systematic study of the activities of new technology based firms in the 1980s, he found major differences between the operations and trajectories of biotechnology and software firms (relatively close to our digital media sector).

Biotechnology is a clearly distinct sector. Biotech firms tend to maintain close links with their founders' previous employers, particularly in the area of research. The intense level of regulation significantly increases the length of time and costs involved in innovation which means that biotech firms require very significant amounts of external funding and operate to a much longer time horizon than in the other two sectors. They are more likely to introduce external executives at an early stage and to develop a formal business plan. Overall, their product development lead times are by far the longest, their capital requirements are the greatest and they rely most heavily on formal scientific knowledge.

Software firms are in many respects the opposite of biotech firms. They continue to be based heavily around the founder's expertise and interests and rely much less on formal R&D, internal training and external funding (unless they are pursuing a particularly aggressive growth strategy). They have the fewest links to universities and the most to industrial firms. Their time horizons are shorter and the level of external support they require, although substantial, is much less. The earlier identified move to co- and self-regulation has placed the onus on digital media companies to have sufficient expertise and knowledge of their markets and their regulatory structures in-house or to work collaboratively with media publishers and firms who have this local knowledge. For SMEs the latter is the dominant trend.

Clearly each of these sectors have different requirement in terms of funding, R&D, technological networks and links to universities and other sources of public research. The differences go further than this to shape employee relations and learning cultures. A study of firms in Silicon Valley in the mid-1990s found similar differences among firms in a range of 'high tech' industries – including telecommunications, computer, medical and semiconductor companies (Baron et al. 1996). Computer and semiconductor companies tend to adopt an 'engineering' model of management – where staff are organised into teams and motivated by the opportunity to do interesting work. Medical companies (closest to biotech) are more likely to adopt a 'star' model – focused on attracting the 'best' researchers and providing them with a great deal of autonomy. Sectoral differences extend therefore to the models of learning and management-employee relations that firms tend to use.

Each of these dimensions – knowledge bases, the central occupational group / organisation of communities, and the organisation of the firms and market – will profoundly shape the different sectoral pathways to innovation.

3 RESEARCH DESIGN AND PROCESS

The study follows a case-study design as defined by Yin (1993, 2003). Yin defines the case study as an empirical inquiry that investigates a phenomenon within its real-life context, especially in situations in which the boundaries between phenomenon and context are not clearly evident, and that uses multiple sources of evidence. What distinguishes Yin's conception of a case study from traditional quantitative research follows from the concern with context. The richness of the context means that the study will have “more variables than data points" (Yin, 1993, p. 3) with important implications for generalisation. Furthermore, the richness means that the study will likely use multiple sources of evidence that can be quantitative or qualitative. This makes statistical analysis difficult or impossible.

Yin’s case study design or approach is more than a method of data collection - it covers the logic of design, data collection techniques, and specific approaches to data analysis. Yin’s case study approach should not be equated with qualitative research or confused with specific methods of data collection such as ethnography or participant observation. “Some qualitative research follows ethnographic methods and seeks to satisfy two conditions: (a) the use of close-up, detailed observation of the natural world by the investigator and (b) the attempt to avoid prior commitment to any theoretical model. However [case studies are not] limited to these two conditions. Instead case studies can be based on any mix of quantitative and qualitative evidence. In addition, case studies need not always include direct, detailed observations as a source of evidence” (Yin, 2003, p. 15)

What distinguishes Yin's concept of a case study from ethnography and grounded theory is the idea that case study research can be explanatory and test theory. Along with exploratory and descriptive case studies, he distinguishes explanatory case studies (as one form of causal case studies) oriented to the testing and advancement of theory and thus part of a cumulative body of knowledge rather than isolated empirical enquiries. The traditional idea is that research questions that posit a strong causal relationship between variables suggest some form of experimental research design and the use of statistical tools to make inferences from one's sample to the larger population (Nunam, 1992). Yin on the other hand argues that cause-effect relationships can also be researched with case studies. Exploratory and descriptive can be used to address “what”, “where” and “who” questions while the explanatory case study can be used to answer “how” and “why” questions

According to Yin, causal case study research favours explanatory theories, particularly complex ones. Here the researcher uses existing explanatory theories to determine the causal relationship. The case study is characterised by a strong adherence to the hypothetico-deductive framework. As in traditional quantitative research, theoretical framework and hypotheses/postulations are developed in advance of the data gathering and data analysis process, and the research design involves testing of these hypotheses. However, the explanatory theory in a causal case study involves a different approach to design, generalisation, testing and validity.

As regards the problem statement, the explanatory case study approach is most appropriate for 'how' and 'why' questions, i.e. questions that are looking for an explanation rather than a prediction of a phenomenon (Yin, 1984). Theories lead to the formation of a set of causally linked hypotheses together representing the target research pattern or target hypothesis of the study. The explanatory case study involves a specific approach to testing and generalisation, generally referred to as analytical generalisation (Hamel, 1993, Yin 1993). This can be contrasted to the traditional quantitative approach of statistical generalisation. In a traditional quantitative survey design the individual cases represent a sample of a larger population to which the findings are generalised after statistical testing. This approach is not suitable for a case study. A case study calls for intensive amounts of data about a small number or a single unit of analysis. The number of subjects or data points is so small that it cannot outnumber the variables of interest. In other words, "the degrees of freedom would always be insufficient compared to the number of variables" (Yin, 1993, p.81). Furthermore, many of the required data cannot be readily converted to numerical values. Both characteristics make statistical testing and generalisation to a larger population irrelevant.

Instead, "generalisation of the results of a case study is made to theory, and not to populations" (Yin, 1993, P.79). This means that the researcher identifies a theory that the case study is trying to test, rather than regarding the individual case studies as data points or part of a sample. The theory will provide a predicted pattern of events, which becomes a series of benchmarks, a template, against which empirical results can be compared. In this way theory can be tested with empirical evidence collected from a single-case study. However, multiple case designs are likely to be stronger than single case designs and “trying to use even a two case design is a worthy objective” (Yin, 2003, p. 19). Multiple case designs are based on a replication logic rather than a sampling logic. Replication simply yields greater confidence in the robustness of the theory.

The remainder of this section details the case study research design that has guided the research project. The design includes both descriptive and explanatory elements as reflected in the main research questions:

Q1 What are the main socio-spatial structures of knowledge flow and innovation in the Irish biotechnology and digital media sectors in terms of type of actors, knowledge interaction, location, etc.
Q2, How are these social and spatial structures of knowledge flow and innovation shaped by: the type of knowledge base, the organisation of knowledge communities and central occupational group; and the organisation of firms and markets?

In relation to the knowledge base element of the “how” question, a substantial body of research has been carried out leading to theories regarding the impact of different types of knowledge bases and modes of knowledge creation on the spatial structure of knowledge flow in innovation. These theories, outlined above, led to the formation of the following target hypothesis:

> The Irish biotechnology industry and digital media industries are both characterised by innovation projects that involve different modes of knowledge creation, appearing in different

> intensities, during different phases of the innovation project. In the biotechnology industry the analytical mode of knowledge creation is relatively more dominant while the innovation activities in the digital media industry are characterised by a greater dependence on the synthetic and symbolic knowledge bases. This has implications for the spatial structures of the knowledge flows and innovation. Most activities in the biotechnology industry, drawing more on "know-why" type of knowledge, tend to be relatively less sensitive to geographical proximity. Activities in the digital media industry tend to be more sensitive to geographical proximity. Here face-to-face interaction benefits both the exchange of "know-how" and "know-who" type of knowledge, both intentional and unintentional.

The unit of analysis is *the successful innovation project*. We 'select on the dependent variable' to show examples of successful innovation and ask what variations exist in pathways to innovation and what explains those pathways. The methodological decision to focus on 'success stories' means that we are focusing on the variety of pathways to 'success' (and the various socio-spatial organizational forms compatible with 'success'), rather than on a comparison of the factors shaping whether firms innovate or not. Innovation projects potentially involve a range of actors, including firms, workers, firm networks, person-to-person networks, technical communities, universities and other institutions.

We left the structure of innovation production, and of the socio-spatial relations which constitute it, methodologically 'open'. In other words, we attempted to avoid building in to the research design any particular actor or institutional form as the main 'home' of innovation. We did not begin with the presumption that the firm, the network, the technical community, the region or any other such entity is the primary actor in the innovation process. In fact, we sought to design our research such that we could assess how these various entities interacted with each other to shape the overall innovation process.

We adopted a multiple-case design involving two subgroups – projects in biotechnology and digital media. Within each sector we conduct a number of case studies serving a literal replication logic (Yin, 2003). Project selection was based on a review of secondary material and a set of initial interviews with industry experts in the Irish industry. This provided an overview of the two sectors and its main sub-sectors as well as a list of companies for case study selection (see the following section for an overview of the two sectors and further detail regarding the development of the universe of firm used for case study selection). The unit of analysis for the research is innovation *projects* but we had no "universe" of projects. Instead, we used the list of companies to steer the case-study selection, which was strongly informed by the opinion of the industry experts. The case-study selection was guided by a number of selection criteria:

1) Given the focus the OPAALS research project on SMEs the selected innovation projects should have a strong involvement of SMEs in Ireland. I.e.

a substantial part of the innovation project should be carried out by the Irish SME or research group.

2) Part of the reason for selecting Biotechnology and Digital Media as the focus of our study was that the literature suggests that the two industries could serve as examples of industries dominated by different knowledge bases or modes of knowledge creation. Therefore, one of the criteria was that the project was a "typical" case of such a knowledge base. This means that the project is not "representative" for the entire industry (such a project does not exist in any case)
3) Having said this, in order to increase the policy relevance of the study in the Irish context we wanted to include projects from a sub-sector that is well represented in Ireland.
4) We were hoping to select innovation projects that are in an advanced stage, preferably already on the market.

The selection of innovation projects obviously raises question as to how we define innovation. We adopted a broad definition: Innovation processes involve the exploration and exploitation of opportunities for new or improved products, processes or services, based either on an advance in technical practice, or a change in market demand, or a combination of the two (Pavitt, 2006).

Based on these criteria, in relation to the digital media sector the research team decided to select four projects from animation companies. These were expected to be involved in projects "typical" for the symbolic/synthetic knowledge bases. In relation to biotech, the research team planned to select four projects from the bio-pharmaceutical sub-sector[2]. This is the main sub sector in the Irish biotechnology industry, dominated by SMEs, and it was expected that most companies in this sub sector were involved in projects that could be considered "typical" of the analytical knowledge base. However, the criterium to select innovation projects that were at an advanced stage proved problematic in this sub-sector. Most Irish SMEs in this sub-sector are at a very early stage of their development. This, in combination with the fact that some suitable companies declined to co-operate, meant that we needed to include projects involving companies from other sub sectors. Here, the most important criterium was the extent to which the company was expected to depend on the analytical knowledge base and to which the company was "biotechnology enabled". The eventual group of case study companies included two bio-pharmaceutical companies, one bio-diagnostics company and one biotechnology services company (which has developed its own diagnostics product).

As regards data collection methods, the case-studies took the form of "innovation biographies" - in-depth micro-studies tracing back the history/genealogy of particular innovations. We were concerned to see how the social spatial relations of innovation vary over time throughout the innovation process. We therefore started with the innovation itself and carry out an innovation biography that explored how the innovation emerged over time. Taken together, the innovation biographies gave us a picture of the particular 'innovation coalitions' that underpin innovation processes and outcomes. This allows us to 'map' the actors that are involved in the innovation process at different stages, how they interact with each other and how their boundaries

[2] For sectoral data that supported the selection process see section 4

shift and change over time. This will therefore allow us to examine how firms, inter-firm networks, technical communities, universities, industry associations, government labs, individual contractors, etc relate to one another at different stages of the innovation process by creating a ‘map’ of the relations at different stages. We will also be able to examine the shifting spatialities of the process at different stages by placing the various actors within different spatial scales (local, national, regional, transnational etc).

During the first phase of the research projects interviews were conducted with 15 industry specialists. Where permission was granted all interviews were recorded. The aim of the interviews was to obtain a first impression of the relevance of the conceptual framework and target theory in the two industries and to guide case-study selection. In the second phase of the research, for the eight innovation projects, 28 interviews were conducted with staff from relevant companies, universities and other institutions in Ireland. All interviews were recorded, transcribed and coded for analysis. Interview data were supplemented and triangulated with information from secondary sources, notably annual reports, journals and Internet sites. All companies were offered the opportunity to comment on the reliability of the case study, and most companies did so. This report discusses the data of all eight innovation projects but only six case studies are included.

4 THE IRISH BIOTECHNOLOGY AND DIGITAL MEDIA INDUSTRY

This section introduces the biotechnology and digital media sectors in Ireland and provides further support for the for case study selection process

4.1 Modern Biotechnology

This study focuses on the modern biotechnology industry. The "modern" refers to the post-genetic engineering era, that is after scientists had developed the knowledge techniques and tools to intervene directly at the gene level (Laage-Hellman et al., 2004). The definition of the modern biotechnology and the operationalisation of such a definition are the subject of intense debate and controversy. A diversity of definitions exists. Some studies focus on particular industries while others argue that modern biotechnology should be regarded as a diverse set of knowledge bases and an enabling technology that has affected different industries (Brink, et al., 2004).

The OECD (2006) applies a combination of a single definition and a list based definition. Biotechnology is defined as the application of science and technology to living organisms, as well as parts, products and models thereof, to alter living or nonliving materials for the production of knowledge, goods and services'. It has been rightfully pointed out that this would encompass not only most biomedical R&D and commercial activity that involves laboratory animals or humans but also virtually all of agriculture, baking that uses yeasts, and the production of fermented beverages and foods, including beer and yogurt (Millar, H. 2007). In order to narrow the definition to modern biotechnology the OECD employs a list based definition that includes various techniques and activities: synthesis, manipulation or sequencing of DNA, RNA or protein; cell and tissue culture and engineering; vaccines and immune stimulants; embryo manipulation; fermentation; using plants for cleanup of toxic wastes; gene therapy; bioinformatics, including the construction of databases; and nanobiotechnology.

In terms of output or application, biotechnology tends to be coulour coded into red, white, green and blue biotechnology, although their does not appear to be a full agreement regarding the precise meaning of the colours. Red tends to be linked to medical biotechnology – used in the diagnosis and treatment of diseases. White biotechnology (sometimes referred to as grey biotechnology) focuses on using biological organisms to enhance industrial processes, often with an environmental nuance. Green tends to be linked to agricultural and food production biotechnology. Finally, blue is linked to aquaculture and marine biotechnologies.

Even if we agree over a definition of biotechnology we run into the difficulty of defining a biotechnology firm. When do we call a firm a biotechnology firm? Most firms use various technologies and produce various applications. Some firms produce or sell products that include a biotechnological agent but this agent is developed and manufactured by another company. Biotechnology is an "enabling technology". Many companies are enabled by biotechnology but the percentage to which they are enabled

by biotechnology differs from company to company. As a way out, many studies limit the population to core or dedicated biotechnology firms. However we can not assume that all activities and outputs of these firms are related to biotechnology while the biotechnology activities of larger diversified firms can be substantial (Arundel, et al., 2007; Brink et al., 2004).

Partly due to the lack of official statistics and partly due to the ambiguous nature of the definition it is difficult to determine the size of the Irish biotechnology industry and its sub-sectors. Enterprise Ireland, provides a directory of biotechnology companies on its *Biotechnology Ireland* website. The directory lists hundreds of companies but includes many non-biotechnology companies, such as accountants and consultancy firms. The Circa Group Europe conducted one of the first attempts to inventorise the modern biotechnology industry InterTradeIreland (2003). The definition of modern biotechnology employed was "the application of molecular biology, cell and tissue culture or recombinant DNA techniques to organisms, cells or parts thereof in the manufacture of product or a as a component of service provision. Only companies whose staff skills/expertise or manufacturing processes were predominantly based on modern biotechnology were selected and surveyed. The report states that 41 companies in the Republic of Ireland responded to the survey but it is not clear what this means for overall size of the industry in Ireland. We do learn that in terms of number of companies pharmaceutical-biologics (12) and diagnostics (13) are the main sub-sectors, followed by agri-food (8), pharmaceutical services (6) and bio-environmental (2). 18 of the 41 respondents were foreign owned companies.

More recently the same consultancy group conducted a second survey (Irish Bioindustry Association, 2008). Here they used the above mentioned OECD definition. Only companies involved in R&D were included in the survey. Thirty-eight companies were identified according to this criteria but it is not clear from what sources this universe of firms was constructed. The results show that red biotech is by far the largest sub-sector in Ireland with 74% of the respondent firms classifying themselves as medical and a further 4 percent as medical and agricultural.

As part of the current research project and to support case-study selection the research team conducted its own inventorisation of the biotechnology industry. The base list of companies was based on the InterTradeIreland report and the Biotechnology Ireland web-site. All companies that matched the OECD definition and that were R&D-active in Ireland were included in this initial list, no matter what their size. The list was checked by industry experts which lead to the removal as well addition of companies. Based on information provided in previous reports, internet search and information obtained from industry experts, companies were categorised in five sub-groups - bio-pharma, bio-diagnostics, green biotech, white biotech and blue biotech. The bio-pharma and bio-diagnostics sub-sectors were purposefully distinguished because the initial interviews suggested that they are characterised by different knowledge bases and different regulatory regimes (see below). Biotechnology services were distinguished because of the fact that some services companies are providing a more or less routine service and are not actively involved in innovation processes. On the other hand some service companies are actively involved in innovation while in other cases the service provided was based on an initial innovation of the company.

Table 4.1 Research-active biotechnology companies in Ireland (case projects in brackets)

Dominant activity	*Indigenous companies*	*Foreign companies*	*Total*
Bio-pharma	17 (including cases 1 and 3)	16	33
Bio-diagnostics	16 (including a case not reported in this deliverable)	5	21
Green biotech	3	7	10
Biotechnology services	10 (including case 2)	-	10
White biotech, blue biotech and unknown	6	-	6
Total	52	28	80

***Source*:** compiled on the basis of information obtained from InterTradeIrleand (2003), Biotechnology Ireland website and interviews with industry experts**.**

The resulting list of 80 biotechnology firms is presented in Table 4.1. This list is clearly larger than the lists included in the earlier surveys. The discrepancy is most likely related to the inclusion of all firms, including all start-up and early stage campus companies. The list includes 28 foreign-owned companies. Most of these companies are subsidiaries of large multinationals and have a strong manufacturing focus. The R&D activities tend to be concentrated in process development. The main indigenous sub sectors are bio-pharmaceuticals and bio-diagnostics. The bio-pharma sub-sector is even more dominant than the table suggests since the majority of the indigenous biotechnology services companies are active in biopharmaceuticals. As regards size the data are incomplete. But what we know is that all sub sectors are characterised by a strong involvement of SMEs. All but two of the indigenous companies are SMEs. It is estimated that the majority of indigenous companies in the list are micro-enterprises, employing less then 10 staff - often start-up companies or campus companies. The majority of the other indigenous companies are small enterprises, employing less than 50 staff.

The interviews with industry experts tell us that most companies in the bio-pharma sub-sector are relatively strongly "biotechnology enabled" while the core competence of a substantial number of bio-diagnostics companies is concentrated in the area of chip design or engineering, rather than biotechnology. Most Irish SMEs in the bio-pharma sub sector are at a very early stage of their development.

4.2 Digital Media

Digital media as a concept emerged in the mid to late 1990s and was used to refer to new media or 'multimedia' artefacts like internet web sites and computer games. However as traditional mass media like television, film, music and animation started to move from old analogue platforms to digital platforms distinguishing between analogue and digital media began to make no sense. All media were becoming digital, even if the original content was created in analogue form.

Definitions of what constitutes the digital media industries generally include a range of media and entertainment industries and some ICT industries. However the use of the concept varies and it can be applies quite narrowly to include mass, new media and some software activities or broadly to include all media, software and ICT related activities. In the UK the concept of the 'creative industries' has emerged in policy circles but this concept is very broad and includes traditional media, new media, arts and crafts and software industries more generally.

All forms of digital content could be easily combined or recombined leading to a proliferation of new forms of hybridized content and new distribution platforms like the internet and wireless which means that digital media products and services can be accessed on demand across borders and time zones. Today digital media and the processes of production and consumption which emerged around them in the early part of this century have become 'thoroughly embedded and routinized in the societies where they are widely used' (Liebvrouw and Livingstone, 2006).

In Ireland a review of key institutional actors and policy documents signal that 'digital media', the 'digital content' industry and to a lesser degree informatics remain the dominant concepts (Forfas, 2002 and 2007; Interviews with industry experts). In the policy body Enterprise Ireland there is a person responsible for the 'TIME' sector which includes telecoms, internet, media and edutainment software.

In a 2002 report published by the industrial policy making body Forfás, the concept of the 'digital content' industry was used. The concept was defined broadly to include a range of sub-sectors e.g. entertainment, education, consumer information and business/professional related content and to include companies involved along the value chain, from content design and authoring to packaging, publishing, marketing and distribution. Entertainment included animation, games, digital film, digital TV and music while education included e-learning companies. Included in the other sub-sectors was internet and wireless publishing and corporate communications. A key difference from the creative industries concept lies in the exclusion of traditional arts and crafts and non-content related software production from the latter.

In 2002 it was estimated that there were a total of 282 significant companies in the digital content sector in Ireland, employing between 4,000 and 4,500 employees. The industry is mainly comprised of indigenous companies, which accounted for 84% of the companies and the most significant sub-sectors by total numbers of companies are in business publishing/web based services, digital television and film and e-learning. Almost 90% of the industry is located in Dublin in the south city centre. A minor cluster exists in Limerick in the e-learning area. A majority of the companies are focused on the Irish and UK markets. The report stated that the industry 'is at a relatively early stage of development, and largely comprises of micro-enterprises fragmented across a range of entertainment, education, consumer and business information sectors. The most notable exception to this is e-learning, Ireland's most successful Digital Content sector (Forfas, 2002).

Growth projections in these reports were optimistic with annual average growth rate of 29% in the sector expected between 2001 and 2006. In face to face interviews Irish digital media companies were less optimistic and anticipated slower growth in employment. Significantly, in a study of 23 digital media companies across the

different sub-sectors almost 80% of employees were full time with almost 15% on permanent contracts and the rest on temporary contracts. Only one of these companies had a formal R&D department.

When one examines employment by occupation within a sample of these companies the mix of occupations and skills becomes apparent. The most significant occupations included authoring and design as well as sales and marketing roles while programming jobs while important, constituted a much smaller percentage. Interviews with 23 media companies (20 Irish firms and 3 UK firms) across a range of sectors in 2002 found that:

- Media content authoring and design occupations accounted for 34% of the total jobs in these firms (292 jobs out of a total of 866).
- Management, sales and marketing occupations accounted for 20% of the total employment.
- Software development, IT and system support accounted for 15% of the total jobs.
- Quality control and testing roles accounted for 19% of the total. (McNaboe, 2005)

The report concluded that while a combination of technical and design skills are present in Irish digital media companies, many lack management and business expertise and face significant barriers networking internationally, in the absence of a strong local market McNaboe 2005). Unfortunately more recent figures or studies are not available for this sector in Ireland.

Interviews with policy makers in the digital media area in 2008 indicated that the most significant sub-sectors in Ireland in terms of employment and turnover were e-learning and telecoms although the greatest numbers of companies were in media and entertainment. Typically the Irish companies had few links to universities but were focused on product or service creation and international markets. Key digital media multinationals located in Ireland include Google, Microsoft, Vivendi, Activision, ebay, amazon and AOL. These companies are serving the European or global markets and are focused on localization, data management and distribution. There are a number of publicly funded sectoral networks which are attempting to encourage greater knowledge flow between indigenous and multinational companies and universities including ELITE - a CEO forum in e-learning, IMS-ARCS which focuses on instant messaging, a digital media forum and a mobile TV pilot network.

A significant policy initiative since the 2002 report has been an attempt to develop a digital media cluster in south Dublin known as the 'Digital Hub' which was launched in 2002. By the end of 2005 this cluster had 50 companies employing approximately 400 people (The Digital Hub, 2007). This cluster aimed to have 100 companies and 900 employees by 2008 (the Digital Hub, 2007). This cluster included companies in the games, learning, wireless and entertainment sectors and again at all stages of the value chain. An attempt to develop a European offshoot of the MIT Media Lab in this cluster failed, both financially and in terms of stimulating local innovation, and is currently being replaced by a National Digital Media Research Centre involving Irish universities (Kerr, 2007). Interviews with experts in the Digital Hub have indicated

that ad hoc collaboration is starting to emerge in this cluster and an internally commissioned research report on companies in the hub is due to be launched shortly.

Given that the Irish digital media industry has such a small home market it must link internationally to both produce and distribute its products and services. A government commissioned report on the international digital media industry noted that the industry was worth $965 billion in 2004 and would grow by at least 50% by 2009. The key driver identified was technology, from advances in mobile and console technology to the development of the internet and broadband. The report anticipated increasing project sizes and costs in games, the commoditisation of basic skills and tools in areas of animation which would be increasingly outsourced to Asia-Pacific territories and changes in user behaviour and demands as key trends (Forfas, 2006). The report also noted that access to skills, rather than access to education and research, was a key influence on location. Additional factors included lifestyle, cost base and the location of firms target market (*ibid.*).

5 SUMMARY AND DISCUSSION OF THE CASE STUDIES

5.1 Introduction

This chapter summarises and discusses the findings regarding the socio-spatial foundations of knowledge flow and innovation in the biotechnology and digital media industry as presented in the case studies. We start by summarizing and comparing the patterns of knowledge flow in the two sectors on a number of dimensions – the actors and their locations, the sources of knowledge and the mode of knowledge exchange, including the salience of digital environments. After this we discuss how the differences in the patterns between the two sectors are shaped by the underlying knowledge base (5.3) the central occupational group and knowledge communities (5.4), the organisation of firms and markets (5.5), and the institutional context (5.6). The chapter finishes with some summary comments regarding the role/salience of the regional/national ecosystem in the innovation processes.

5.2 Patterns of Knowledge Flows and Innovation

This section summarises the pattern of knowledge flows in the case studies (as reported in the appendix – sections 7-12) and identifies the key patterns in the two sectors. We start with a summary of the type of actors and their location. For a tabular summary of the individual cases we refer to the tables in the individual case studies. Although collaborative actors can be an important source of knowledge, they are certainly not the only source. Therefore subsection 5.2.2 provides a comparison of the main sources of knowledge. The subsequent subsection (5.2.3) compares the modes of knowledge exchange of actors located at different distances. The focus is on the relative importance of face-to-face contact, buzz and the use of digital environments and how the model split is linked to the geography of actors.

5.2.1 Type of actors and their location

In spite of the variety of cases, notably in the biotech sample, it is possible to identify a number of differences and commonalities between the two industries in terms of type of actors and their location. Both industries are characterised by ‘open innovation’ with all cases involving a substantial number of external actors.

In the biotech group we can identify two cases where the initial stages of the innovation trajectories are very much the terrain of academic departments after which the locus shifts to dedicated biotech firms (spin-out). One innovation trajectory (case 3) starts at a medium-sized biotech company but related work was conducted at ‘competing’ university departments. Case 1 is characterised by a substantial level of external collaboration from the early stages but in the other two cases, the early stage(s) are conducted relatively autonomously.

For the two bio-pharmaceutical cases the most important partners are clinical research groups, commercial analytical service providers and, later, clinicians, clinical research organisations and pharmaceutical companies ("big pharma"). External partners are mainly selected on the basis of the expertise they can bring to the project. One important reason for external partnerships towards the end of the innovation trajectory is finance. Towards the end of the trajectory, the stage III clinical trials are too costly and their outcome too uncertain for small dedicated biotech companies to go it alone. For this reason the small dedicated biotech firms rely on large multinational pharmaceutical companies with the necessary financial clout to finance the trials and bring the product to market. In all biotech cases the constellation of actors is not determined at the beginning of the trajectory. At various stages new actors enter and the co-ordinating actor can change (as in cases 1 and 3). In the food diagnostic innovation (case 2) most of the science is conducted by the focal company. The main external partners are small companies with a core competence in engineering. The initial partner clients fulfil a facilitating function.

In terms of location, from a focal firm point of view, in all of the cases, during all stages, most of the core external actors are global (i.e. outside of Ireland). Cases 1 and 3 involve almost no local actors and those local actors who are involved are part of a larger group of global partners playing a similar role. In general, the external actors are selected on the basis of the expertise they can bring, access to patient groups and/or financial clout they can provide – and which is required to bring a project through clinical trials and to the market. The food diagnostics case (2) involves one local actor during the last stage of the trajectory.

The three innovation trajectories in the animation group start with small, very young, animation companies. The first stage is used to identify and forge partnerships with the main project partners including other animation companies, distribution companies, broadcasters and merchandising rights companies. The constellation of core actors changes little during the innovation trajectory, although the intensity of their involvement does change from stage-to-stage. The animation companies involved are all small to medium sized enterprises. The broadcasters, distribution and merchandising companies can either be large or small, but each production network involves at least one large multinational company with the necessary financial clout to finance part of the production costs. At the start of the production phase the animation companies recruit a substantial project team (crew), possessing most of the required skills. However some tasks, such as script and music writing tend to be outsourced to free-lance operators. In two cases the actual animation during the production stage is outsourced to more cost-competitive animation studios.

In terms of location, again from the point of view of the focal company, nearly all significant co-producers, broadcasting clients, distributors, merchandising partners, contract animation partners and script writers are located overseas. In case 5 the focal company has a co-production agreement with an Irish animation company that takes care of the post-production but the most significant co-producer is located in Canada. In case 6 the Irish broadcaster was among the first clients, but the more influential broadcaster/distributor was located overseas. Compared to the biotech cases, the tendency to select foreign partners is less driven by a search for complementary expertise. The main drivers for choosing an overseas partner include the financial and fiscal incentives that an overseas partnership can provide, the

potential cost-savings related to operating in low-wage environments and the fact that the Irish market (broadcasters) is too small to support the development of animated television series.

5.2.2 Sources of Knowledge and Finding Partners

External collaborators and partners can be an important source of knowledge but they are not the only source of knowledge. *The case studies identify the most important sources of knowledge during the various stages of the innovation trajectories and reveal important differences between the two industries.*

In the biotech cases, the initial stages of the innovation trajectories are very much the terrain of academic departments. In two cases the research groups work relatively independently. The main source of (know-why) knowledge of the principal investigators are the academic journals. Other sources include discussions with other members of the global scientific community and, to a lesser extent, colleagues in the same institution. Where the research involves collaboration with other academic research groups, the collaborators can also constitute a source of knowledge.

Academic journals and members of the global scientific community remain an important source during the next stages of the projects, although the intensity to which this source is used decreases. In all cases, at least some of the company founders or key employees retained links or returned to academia and these individuals continued to act as an important gateway to the academic literature. Industry and trade literature becomes an additional source of knowledge. In the two bio pharmaceutical cases, external clinicians and their research groups become an important source of knowledge as they conduct part of the research and by expressing opinions regarding unmet market needs and the prospects of the drug in the market (although not the eventual end-users, these clinicians are the most important market intermediaries as they possess crucial knowledge about the drug's potential success in the context of competing products). Market related knowledge is also obtained from patent databases.

Finally, the Scientific Advisory Board constitutes a crucial source of know-why, know-who and industry knowledge. At the point of project selection the members of the board give their opinion about the chances for scientific and commercial success. Much of this knowledge is codified but this does not mean that it is accessible to all. At a later stage the Board provides important knowledge about designing the clinical trials and setting the analytical plan. Although this includes scientific knowledge, it also includes important knowledge about the (highly regulated) processes of bringing a product through clinical trials. This may be best described as industry specific business knowledge. Closely related to this is their know-who about the relevant external advisors clinical trials locations, clinical research organisations, etc. Finally, during the course of the project, some of the members regularly advises research staff about specific issues (know-why), but this is not the core function of the board.

In the food diagnostic project (case 3) FoodGen does receive important inputs from the end-users, the meet-plants and retailers who facilitated their research by providing information regarding operational procedures in the industry. In addition, external engineering partners are an important source of complementary knowledge. Here too,

market and industry specific knowledge is crucial for the success of innovation and the Irish focal company has installed a Business Advisory Board which includes high profile business actors and experts in various commercial sectors. The Board functions as a crucial source of market related knowledge, supporting the innovation process.

In the two bio-pharmaceutical cases the Scientific Advisory Board clearly plays an important role in finding partners. However, some of the core partners, as well as most of the service laboratories and engineering companies (in case 2), were actually identified through inspection of industrial literature and directories, typically using the Internet. Others were identified through referral. Finally, one of the core partners in the food diagnostics project was identified, coincidentally, during a visit of a local laboratory where the partner's system was in use.

The sources of knowledge in the animation cases are very different from those in the biotechnology cases. Most of the artistic work during the initial development stage is done largely in-house, typically by one or two artists. The main source of knowledge is the embodied knowledge of the artists (developed during previous work and education). Inspiration is obtained from a wide variety of sources. General ideas can come from random sources, including TV programmes, DVDs, the Internet and blogs, trade journals, children playing, children's book, computer games, public markets, etc. Only one artist (in case 6) accorded a role to the inspiring environment (Dublin). For more specific (to the particular TV series) ideas the artists rely on many of the same sources, as well as script writers and feed-back from the broadcasters and distributors. One of the focal companies interacted directly with the end-users (children in primary schools) to test initial ideas. However, knowledge of the audience is largely mediated through the client broadcasters and distributors who know their target audiences and undertake tests.

Due to the project nature of the work and the changing constellation of actors from project to project, know-who type knowledge is even more important than in the biotech cases. Much of this knowledge is embodied in the core staff of the company and, where relevant, the business development team. This knowledge is developed and kept up-to-date by visiting international trade fairs and by being involved in previous projects. External partners, notably the distributors and co-producers, can represent an important additional source of know-who type knowledge, notably where the focal company is relatively young and has a limited network. The case studies suggest that the relative importance of external partners as a source of know-who partly depends on the age of the firms. Relatively young companies have been involved in a limited number of projects and have a limited reputation which limits know-who knowledge. Other, less important sources include online professional networking sites and word-of-mouth between producers

The success of the innovation depends on skilled (in some cases specifically skilled) and experienced crew. Because most of the crew changes from project-to-project, know-who type knowledge is important for recruitment as well. Much of the knowledge regarding potential candidates is embodied in the firm's core staff (or lists) developed during involvement in previous projects and visiting trade fairs or events. Other recruitment media include on-line international animation forums and the firms' websites and blogs.

The pre-production phase involves many of the same sources of knowledge and inspiration. The network of producers, co-producers, distributors and commissioning clients is now in place. Script writers become the most important external source of ideas. Commissioning clients and broadcasters also provide input, mainly through commenting on the suitability of the material (correctness) for the target audience, rather than providing original ideas. Co-producing animation companies can become an additional source of ideas and know-how. Because most of the crew is recruited for specific projects, this crew can become an important source know-how.

Compared to the biotech cases, the animation companies make little use of direct external advisors (other than their consortium) as a source of (creative) knowledge. The only examples are the internet forums and blogs where artists do post some of their work and receive feedback from other members of the animation community. At the beginning of the production stage typically most of the core innovation and knowledge has already been generated. External actors, notably the (contract) animation studios receive instructions but contribute little new knowledge to the project. Finally, where the post production was done by co-producers these provided important know-how knowledge.

5.2.3 Mode of Knowledge Exchange, Proximity and Buzz

Mode

In the biotech group, there are two cases (2 and 3) where the initial research projects were run autonomously without external partners. Members of the research team did exchange knowledge with academic research groups all over the world involved in similar work, with their academic networks in general and equipment suppliers. The majority of this exchange happened face-to-face, during international conferences and workshops. This contact served nearly exclusively the formation of ideas and hypotheses. Knowledge exchange with peers and former bosses abroad occurred both by phone and face-to-face. Knowledge exchange with the local academic world tended to occur face-to-face or by phone but the face-to-face contact with local academics was not particularly frequent. One of the research groups, although located on a university campus, had very little contact with the local academic community. This may have had something to do with the fact that the project was in the hands of a commercial company. The scientists were not free to discuss the commercially sensitive knowledge. There was not enough organisational proximity for knowledge flow to occur.

In case 1, the initial stage involved collaboration with external academic research groups all over the world. This involved a substantial amount of communication by phone and email. The principal investigator would meet some of his counterparts twice a year. Meetings were often organised to coincide with conferences. A number of his counterparts he had never met. Other researchers in the group maintain regular contact via phone and email but very limited face-to-face contact.

During the subsequent stages the picture emerging from the two bio pharmaceutical cases is somewhat different from that of the food diagnostics case. In the bio pharmaceutical cases, coordination and control over the innovation is now located at

small biotechnology companies. The frequency of communication with the external clinical research groups (all but one of which are located abroad), analytical service providers (all but one of which are located abroad), other research service providers, etc. ranges from weekly to once every five weeks. Most of this is organised by email and phone. The amount of face-to-face contact is limited in all cases – ranging from none to twice a year and involves only one staff member. Interestingly, the focal company in case 1 had never met its (single) local clinical partner. Discussions of design of experiments, protocols and data can require a face-to-face meeting, although in the majority of cases such issues are discussed by phone or email. Also of interests, business/contract negotiations and site inspections may be as important, if not more important, as a driver for face-to-face meetings. During the clinical trial stage, the initial organisation of the trials requires a face to face meeting with each of the clinical research organisations, clinicians and regulatory authorities. This involves a single person in the focal firms. The discussion of progress typically involves weekly-to-monthly videoconferences but, depending on the issues, can also require a face-to-face meeting.

In the food diagnostics project (case 2), after the initial stage, the collaboration with two of the (engineering oriented) external partners in Ireland and the UK consisted of very frequent communication by phone and email (a couple of times a week). In addition, the collaboration required frequent face-to-face meetings including extended stays with the UK partner. Some of the contact moments were used to work shoulder-to-shoulder with staff at the partner firms.

Apart from the formal collaborative partners, some of the focal firms did consult academic peers informally. Some of this happened face-to-face, during yearly academic conferences. In addition, scientists occasionally consulted on-line forums or colleagues in their personal/business networks either by phone or email.

Compared to the biotechnology projects, the animation projects involve substantially higher levels of inter-firm communication. During the initial development phase, most of the creative (artistic) activities are conducted by a very small number of staff in a single company and these activities therefore involve limited communication with external partners. However, another core activity during this stage is the development of the consortium of project actors (co-producers, broadcasters/commissioners, distributors, animation contractors) and securing the required finance. These activities involve a substantial amount of communication concerning commercial contractual, legal and project co-ordination. Much of this communication is conducted face-to-face, often during the all-important international trade-fairs, followed (though not always) by meetings at the premises of the various actors. The process involves sustained electronic communication.

During the subsequent (pre-production, production and post production) stages the communication intensifies, particularly between the producers, co-producers, animation contracting studies and freelance script writers. The amount of business related communication is substantially reduced. However, communication about the actual artistic content and co-ordination intensifies. Creating an animated television series involves the development of designs and multiple takes and retakes of episodes. All this material is going back and forth between the producers, co-producers, contract animation houses and commissioning clients that all need to make comments.

Most of this material is transferred electronically (FTP) but the process does involve a substantial amount of email and telephone discussion as well. The core directors and producers have at least weekly conference calls and video conferences with the co-producers as well as daily telephone and email contact. However, the level of face-to-face contact is relatively limited. In two cases the contact between the production company and the co-producers is limited to an initial 'meet-and-greet' and an occasional meeting if major issues arose. One of the focal companies (in case 4) has more face-to-face contact with its co-producers - about four times over the project period - precisely because of the problems with communicating the tacit content.

Collaboration with the animation contract studios in the Far East during the production stage typically required no face-to-face contact other than an initial 'meet and greet', although focal companies did station an overseas supervisor to oversee the activities. Although the knowledge flow involved is of a less tacit nature, the proper coordination of activities is paramount. In one project (case 5) the post-production activities did involve a substantial amount of face-to-face contact between the Irish focal company and the post-production/co-producer in Ireland.

Use of digital environments

Regarding the use of digital environments for external knowledge flow, in the small biotech companies this falls well short of what is envisaged with the development of digital ecosystems. It is limited to the Internet, email and *Skype*. The Internet is used to access the academic literature, for identifying potential supplier/partners, for accessing subject/discipline specific forums and for recruitment purposes. Internally, the small biotech companies use server-based systems to file project-specific documents centrally and different groups of staff have access to specific folders.

Digital environments play a more important role in the animation projects. Email, teleconferencing, *Skype,* and video conferencing are used extensively to communicate with the various project partners. All companies use, or are experimenting with, web-based inter-firm project management tools (*Basecamp, Hobsoft, MS SharePoint*). However, the systems do not operate satisfactorily. Key problems with the current systems include limited speed of transfer, material not transferring properly (partly due to insufficient bandwidth capacity), and the systems not satisfying all the co-ordination requirements of the producers. The Internet (*Google*, forums, blogs) is used to access know-who type knowledge, inspiration and for recruitment as well as communicating the project to the outside world (website and blog). Finally, there are important online systems in place at the international professional events. 'Relationship mediators' and a range of online resources allow attendees to contact key buyers in broadcasters and distributors.

Intentionality and buzz

As regards the intentionality of the knowledge flow, in the biotechnology projects the most vital knowledge is exchanged intentionally. Unintentional knowledge flow appears to have been of limited relevance for the specific innovation trajectories although it does occur and can play a role, particularly during the first stages when most projects tend to be in the hands of academic research groups. International academic conferences are the primary site for such unintentional knowledge flow and

buzz. In one occasion (case 2) local buzz led to the identification of an international partner.

In the animation projects unintentional knowledge flow and buzz tends to be more common and relevant. It is most relevant for know-who type knowledge. Some inspiration type knowledge flows unintentionally as well when artists get ideas from a range of sources, such as watching TV, DVDs, children's books, watching children play, etc. Interestingly, the sites for unintentional knowledge flow through buzz tend to be mainly international and virtual, rather than local. The most important sites for unintentional know-who type knowledge flow are *international* trade fairs and events. Although delegates attend these events with the specific intention to gather know-who type knowledge and develop networks, a substantial amount of knowledge flow is unplanned or unforeseen. The *local* sites that are potentially conducive to local buzz tend to be attended less regularly and their relevance for know-who type knowledge is limited compared to the international events. Further unintentional know-who type knowledge is mediated by industry journals, internet forums and blogs but here too, the foreign sites are far more important than the ones that cater specifically for an Irish audience.

In relation to inspiration type knowledge, although some buzz operates on a local scale (for example watching children, the creative environment of Dublin), again substantial elements operate on an international/virtual scale. Children are observed everywhere and books, DVDs, TV programmes are nearly exclusively of an international nature.

These findings suggest that the conceptualisation of 'global pipelines' versus 'local buzz' (Bathelt *et al*., 2004) is problematic in capturing the knowledge flows. Asheim *et al.* (2007) already pointed out that buzz can be transmitted electronically and face-to-face and can be both local and global. *The case studies of the innovation trajectories in the biotechnology and animation industry show that global buzz and virtual buzz was actually more important than local buzz*. This is not to say that there is no Irish community and that this community is irrelevant for facilitating intentional and unintentional information flow. Case 6 appears to point to the existence of an operational Irish community. It is at least possible that this enhances the level of buzz. However, the community tends to meet during the international events, rather then locally – *the local community buzzes mainly globally, rather than locally*.

Proximity

As to geographical proximity, in biotechnology projects the partner choice appears relatively insensitive to distance decay. Most core external actors are located overseas and are selected irrespective of location, nearly solely on the basis of the specific knowledge they can contribute to the collaboration. There tends to be a very clear division of labour between the different partners. During the initial stage most knowledge flow can be satisfactorily organised via telephone and email and the required face-to-face contact can be efficiently organised through frequent travel and combined with conferences. The rare need for shoulder-to-shoulder work of researchers is satisfied by stationing a researcher short-term at the collaborators laboratory. During the subsequent stages most communication could again be organised satisfactory through email and telephone. The limited need for face-to-face

contact could be efficiently organised through occasional trips involving one member of staff. The collaboration between the Irish food diagnostics firm and the Irish engineering/design partner is the only example where the choice for a local partner may have been driven by a need for frequent face-to-face contact.

In the animation projects, partner choice typically did not appear sensitive to distance decay either. Most of the co-producers, distributors and main commissioning broadcasting clients are located abroad. One of the main reasons for the Irish animation companies to work with overseas co-producers lay in the (national and international) fiscal and financial incentives this brought to the project. In addition partners were selected on the basis of the knowledge/skills and experience they could bring to the series and, in case of the contract animation studios, price competitiveness. The companies were well informed about potential international partners due to regular attendance of international trade fairs, experience in previous projects and referrals or knowledge of the co-producers. Although the development stage involved a substantial amount of face-to-face communication, this was efficiently organised through frequent short-term visits, some of which coincided with trade fairs. The requirement for co-ordination during the production stage was in some cases organised by stationing a single overseas supervisor at the contractor. In one project (case 5) the post-production activities were conducted in collaboration with another Irish partner and this collaboration did involve a substantial amount of face-to-face contact and shoulder-to-shoulder work. However, this was partly driven by the fact that there was no strong division of labour between the focal company and the post-production partner with the directors and the sound director of the focal company having a strong role in the post-production. The choice of the Irish post-production company (and co-producer) was probably more driven by financial/fiscal considerations than by proximity considerations.

We will now consider the salience of non-geographical dimensions of proximity such as cognitive, organisational, social, institutional and geographical proximity (Boschma, 2005). Rather than looking at the way these dimensions facilitate interactive learning and innovation in clusters, in the context of the case studies, it is more relevant to consider the way these dimensions may have acted as a substitute for geographical proximity by facilitating the knowledge flow, innovation and co-ordination among geographically distanciated actors (see also Gertler, 2008)

Maybe the most obvious points relate to social proximity, the embeddedness of relations on the basis of trust, kinship, friendship and past experience. Both the biotech projects and animation projects include evidence of the importance of trust and friendship to facilitate knowledge exchange an innovation. Important instances of building social proximity include the face-to-face meetings during conferences and trade-fairs. The friendships, forged “over a pint” appear very important for securing contracts and knowledge exchange. In addition, in most cases the focal company has at least one meet-and-greet meeting with new partners. One of the main functions of these meetings is precisely to build a level of confidentiality and trust (see e.g. cases 4 and 5). In one of the animation projects (Case 5), the lack of previous experience and trust with one of the new contract animation studios in the Far East, as well as the difficulty of monitoring the contractor from a distance, was a reason to work with an overseas on-site supervisor. Where the focal company worked with studios it could trust, it worked without an overseas supervisor.

Institutional proximity appears relatively less relevant. This can be related to formal institutions (laws and rules) and informal institutions (cultural norms and habits). In the biotech projects, one may argue that the similar IP laws and common regulatory structures (for drug approval and clinical trials) may facilitate knowledge flow and interactive learning among firms in different jurisdictions. In the digital media projects the international taxation and financing agreements between governments actually drives the establishment of international co-productions (although this is not the same as facilitating interactive learning, innovation and knowledge flow). In relation to the informal institutions, in the biotech industry we found some evidence for the idea that individual actors prefer to work with people from a similar culture, although this far from precludes an involvement with actors from other cultures and these projects are not necessarily more conducive to interactive learning and knowledge flow.

"I am inclined to collaborate with people I get on with so what you need is a mix of the role they will play in the collaboration and some kind of sense that you could be, you know, able to get along or yeah the cultural bit I suppose must come into it. But having said that, I would have collaborated with Japanese people who I wouldn't have been able to speak with. […] Now in terms of my own life or my own way of approaching science, it is much more enjoyable if you hit it off with them and have something in common with them and relate to them. But that doesn't necessarily enhance the project" (Interview principal investigator, case 1)

In the animation projects we found examples of cultural distance complicating the knowledge exchange between the focal firms and animation contract studios in the Far East. For example, different cultures have different expressions of joy (case 4). One of the roles of the overseas supervisor was to identify related misunderstandings at an early stage. Working with partners from the same culture also meant that the contracting partner was familiar with the underlying (Anglo-American) children's literature.

Finally, the innovation projects in both industries are characterised by a high level of cognitive proximity which may facilitate interactive learning among geographically distant partners and reduce the need for co-location and face-to-face contact. In the biotech group, certainly the two biopharmaceutical projects involved firms and actors with a similar or related cognitive background. In the food diagnostics project (case 2) some of the partners had a very different cognitive background (engineering). The collaboration with these engineering companies required a relatively large amount of face-to-face communication. The collaboration with the UK-based engineering company had its problems. In the other case, the choice to select the local engineering company was one of the few examples where partner choice was driven by the requirement for face-to-face communication.

Boschma (2005) contends that where the cognitive proximity between partners is too great they may be reluctant to share knowledge. An example of this may be found in case 3. Here the focal company involved was located on a university campus but the knowledge flow between the company and the local environment was limited because of the confidential nature of the commercial project.

5.3 Mode of Knowledge Creation

How are the socio-spatial structures of knowledge flow and innovation outlined thus far shaped by the type of knowledge base? In relation to this question the research worked with the following target hypothesis:

> The Irish biotechnology industry and digital media industries are both characterised by innovation projects that involve different modes of knowledge creation, appearing in different intensities, during different phases of the innovation project. In the biotechnology industry the analytical mode of knowledge creation is relatively more dominant while the innovation activities in the digital media industry are characterised by a greater dependence on the synthetic and symbolic knowledge bases. This has implications for the spatial structures of the knowledge flows and innovation. Most activities in the biotechnology industry, drawing more on "know-why" type of knowledge, tend to be relatively less sensitive to geographical proximity. Activities in the digital media industry tend to be more sensitive to geographical proximity. Here face-to-face interaction benefits both the exchange of "know-how" and "know-who" type of knowledge, both intentional and unintentional.

We divide the discussion of the validity of these ideas in two. Below we begin by discussing the extent to which the innovation trajectories in the two sectors possess characteristics of the different modes of knowledge creation and comment upon the relevance of the knowledge base conceptualisation in general. The subsequent section investigates the link between knowledge bases and proximity.

5.3.1 Modes of knowledge creation in two sectors

In broad terms, the case study findings do provide support for the link between modes of knowledge creation and industrial sectors as laid out in the target hypotheses but the conceptualisation is not without problems.

The biotechnology cases depend strongly on an analytical knowledge base while the digital media cases are characterised by a symbolic and synthetic knowledge base. In line with Moodysson et al. (2008) the cases studies also support the idea that most activities are in practice comprised of more than one mode of knowledge creation and that different modes of knowledge creation are present in different stages of the innovation trajectory, with different intensities. It is actually quite difficult to identify an individual activity that is completely dominated by a single mode of knowledge creation. Even the activities that are most dependent on a single mode of knowledge creation can present some characteristics of another mode (see, for example, stages 1 and 3 in case 1).

All three cases in the biotechnology group include stages that are completely dominated by an analytical mode of knowledge creation with the first stages providing the best examples. Knowledge creation is clearly characterised by unravelling the mechanisms of human processes (know-why). During the initial stages the knowledge generating activities are not aimed at developing a new functional

system, although this changes in subsequent stages. Research projects typically start with a hypothesis that is subsequently tested in theoretically inspired research experiments. Although we agree with Bruland and Mowery (2005) and Pisano (1997) that the theoretical experiments and the clinical trials in the biotechnology industry do rely on experimental methods that are in essence trial and error approaches, the research experiments are driven by a clear hypothesis, tend to be highly formalised, based on protocols. Knowledge inputs and outputs are highly codified, often written up in journal articles or patents.

At the same time, all biotech cases include stages where the analytical mode of knowledge creation is less dominant or where the synthetic mode dominates. In case 1 and 3 we find stages that are characterised by a combination of modes of knowledge creation in single activities. For example, during stage 2, the analytical group at TabPharma (case 3) supports the development of a new functional system (an oral dosage). Conducting the tests clearly involves an analytical mode of knowledge creation and knowledge inputs and outputs are strongly codified. However the main challenge lies in the creation of the tests. This involves a combination of codified and tacit experiential knowledge. It is partly based on protocols and partly involves trial-and-error and tweaking.

In the case of FoodGen (case 2), stages two and three both involve more than one (sub-) innovation process running alongside each other. While one (refinement of the marker system) is again characterised by combination of analytical and synthetic modes of knowledge creation, the others were dominated by a synthetic mode of knowledge creation. The outcome of these knowledge creation activities is concrete and one-off. Some activities are typical engineering jobs, starting with a blueprint that is translated in a prototype which is subsequently tested in the field. The activities have a clear trial-and error aspect. The design effort requires a good understanding of, and contact with, the end-user. Much of the information required has a strong tacit element. The food diagnostics project is relatively more dependent on the synthetic mode of knowledge creation than the two biopharmaceutical projects, a finding in line with the study by Moodysson et al. (2008).

In the digital media cases the first stages are dominated by the symbolic mode of knowledge creation, although the level of this dominance diminishes with each stage. The core innovation is about creating and designing new ideas, images, narrative and metaphors. It is less about creating artefacts with a use value. Companies did exploit, and even develop, novel technologies and software applications for use in the production process, but the innovative element of the successful shows does not tend to reside in the technology.

Knowledge inputs are of an aesthetic nature and demand the ability of symbol interpretation. Important sources include the individual artist's imagination and existing symbols and images obtained from a broad range of sources. The success of the children's series depends, to some extent, on an understanding of children's culture. Only one of the three firms has an R&D group which has been used to develop project specific project tools. The activities rely strongly on tacit knowledge. Know-how, based on experience, is clearly more important than know-why and many activities contain a strong craft element. Although most artists enjoyed some form of animation related schooling, on-the-job training and experience is crucial and

specialisation tends to occur only after education. Finally, because of the strong dependence on external partners for sharing production costs, accessing additional sources of finance, cheap labour and complementary skills and because the actors differ from project to project, know-who type knowledge is crucial.

One could argue that the early stages already contain elements of a synthetic knowledge base. First, the innovation trajectory is characterised by user-centred innovation and strong user-producer interaction. Secondly, the skills base is heterogeneous, both intra-firm and inter-firm.

The salience of the symbolic knowledge base diminishes with each stage. Know-who type knowledge is really most important during the development and pre-development stages. In addition the third (production) and particularly the fourth (post-production) stages are far less creative (i.e. artistic). The third stage (production) is characterised by a combination of the symbolic and synthetic modes of knowledge creation, with the symbolic still having the upper hand. During the fourth (post-production) stage the synthetic mode of knowledge creation comes to the fore, although the activities are not aimed at creating functional artefacts.

The study supports the conceptualisation of synthetic, analytical and symbolic knowledge bases (Asheim and Gertler, 2005; Asheim, Boschma and Cooke, 2008) in general terms but some elements deserve further consideration. The proponents do acknowledge that the categorisation refers to ideal types and that innovations involve more then one knowledge base. Following Moodysson et al. (2008) we set out to show how the different modes of knowledge creation are integrated in concrete innovation projects and how different modes are present in different stages. This has not been straightforward.

Firstly, a substantial number of stages are not clearly dominated by a single mode of knowledge creation and involve a more equal combination of two modes. Secondly, as mentioned earlier, some stages can involve several (sub-) innovation processes, characterised by different modes on knowledge creation, running alongside of each other, which makes it impossible to accord a dominant knowledge base to a particular stage (see case 2). Thirdly, individual activities can have characteristics of different knowledge bases. For example, the refinement of the panel of genetic markers by FoodGen during stage 2 did expand the knowledge regarding the functioning of genetic mechanisms, the activities were theoretically informed, highly formalised, and based on codified knowledge (analytical). But the activity was clearly aimed at creating a new functional system (synthetic). This is related to the fourth point, the fact that the three knowledge bases are not necessarily mutually exclusive, particularly when we include the symbolic knowledge base. Some of the characteristics of the synthetic knowledge base overlap with, or would not be in contradiction to, those of the symbolic knowledge base. For example, the animation companies produce one-off shows, the innovation is user centred and tacit knowledge is important.

A final comment relates to the *types* of knowledge that are covered in the categorisation. A number of the case studies point to the crucial role of market and industry knowledge in successful innovation trajectories. This includes knowledge of (unmet) needs of the market, the ability to connect particular inventions to market

needs, knowledge of regulatory procedures, knowledge of raising finance, etc. For example, the initial invention in the food diagnostics project (case 2) depended critically on the lead researcher's understanding of the structure, functioning and needs of the meat processing industry and, at a later stage, similar knowledge provided by the Business Advisory Board. This type of knowledge, although crucial to the innovation processes, is not covered by the knowledge base categorisation.

5.3.2 Modes of knowledge creation and proximity

The knowledge base conceptualisation implies that different knowledge bases are characterised by different sensitivities to geographical distance for knowledge flow and innovation processes. The target hypothesis was that most activities in the biotechnology industry, drawing more on know-why type of knowledge, tend to be relatively less sensitive to geographical proximity. Activities in the digital media industry tend to be more sensitive to geographical proximity. Here face-to-face interaction benefits both the exchange of know-how and know-who type of knowledge, both intentional and unintentional. In this section we will discuss the extent to which the theoretical ideas and the target hypothesis are borne out in the case studies. For this we reintroduce, in summarized form, some of the material on patterns of knowledge flow (section 5.2)

The tables in the case studies link the knowledge bases to the location of the actors and the importance of face-to-face interaction during the various stages. *The combined nature of the knowledge bases in many of the stages clearly complicates generalisation. However, it is clear that in both industries there is little evidence that partner choice is sensitive to distance decay. From the perspective of the Irish focal companies, nearly all the main partners and customers are located overseas at all stages.*

The projects in the biotech industry broadly match the target hypotheses. Most of the stages that are dominated by an analytical mode of knowledge creation involve distant partners. The biotechnology companies rely heavily on codified knowledge that is publicly available and/or relatively easy to communicate between partners with sufficient absorptive capacity and cognitive proximity. The collaboration generally requires a very limited amount of face to face contact which can be efficiently organised through short trips, sometimes combined with conferences. The rare need for shoulder-to-shoulder work of researchers was satisfied by stationing a researcher short-term at the collaborators laboratory. Collaboration between geographically distant partners is to an extent facilitated by other dimensions of proximity, notably cognitive, social and institutional (see section 5.2.3). The food diagnostics project (case 2) is the only project that involves activities that are dominated by a synthetic mode of knowledge creation. In these instances the collaboration with the UK and Irish partners involves a relatively high amount of face-to-face contact. The choice for the Irish partner may have been influenced by the need for frequent face-to-face contact, partly driven by cognitive distance.

The digital media cases, on the other hand, strongly challenge the target hypothesis. Nearly all of the main partners and clients during the stages dominated by the symbolic mode of knowledge creation are located overseas. These stages involve a

great deal of communication. The tacit nature of the knowledge flow and know-how requires a substantial amount of face-to-face contact, notably during the initial stages of the trajectory, although contract negotiation and co-ordination are at least as important a driver for face-to-face meetings. However, the substantial amount of face-to-face contact is satisfactorily organised through frequent short-term visits, some of which can be combined with trade-fairs. In some instances the collaboration between geographically distant partners is facilitated by other dimensions of proximity, notably social proximity (see section 5.2.3). Co-ordination can be an important driver for face-to-face contact during the production stage and in some cases this was organised through stationing an overseas supervisor, notably where there was a lack of social and (informal) institutional proximity. Overall, the advantages (or rather requirement) of involving overseas partners (related to finance, complementary capability and cost-competitiveness) far outweigh the potential (communication related) advantages that working with local partners would bring.

The post-production stage is the only stage where the synthetic mode of knowledge creation takes the upper hand. In two cases this involves an international partnership as well but in one project (case 5) the post-production activities were conducted in collaboration with another Irish partner and this collaboration did involve a substantial amount of face-to-face contact and shoulder to shoulder work. However, the choice for the Irish post-production company (and co-producer) was probably more driven by financial/fiscal considerations than by geographical proximity considerations (see section 5.2.3).

There is little evidence for the idea that the need for know-who type knowledge influences company location or that partner choice is influenced by a distance decay in know-who type knowledge. In relation to the first point, the Dublin-based firms derive limited know-who related benefit from their location. The local sites that are potentially conducive to local buzz tend to be attended relatively infrequently and their relevance for know-who type knowledge is limited compared to the international events. The most important sites for know-who type intentional knowledge flow and buzz are the international events and international web-sites. Global buzz and virtual buzz are more important than local buzz. In support of the second point, partly due to the exposure to global buzz and intentional information flow at the international events, companies are generally well informed about potential international partners.

The question rises to what extent the limited number of local partners is driven by the relatively small size of the digital media clusters in Ireland and therefore the lack of suitable partners in the locality. Would the focal company have chosen local partners in the counterfactual state of a large local digital media cluster? We believe this is not the case. The evidence in relation to face-to-face communication suggests that face-to-face communication is efficiently organised through frequent travel. Companies are well informed about international partners. Finally, the small size of the Irish market and the fiscal/financial and (in some cases) cost advantages related to international collaborations would weigh far stronger than the potential advantages of local collaboration.

Apart from direct knowledge flow between actors, geographical proximity and clustering can of course be driven by other factors as well. Notably, actors may be attracted or stimulated by a common knowledge resource. In relation to the biotech

projects, the local universities may well have been more important than direct knowledge flow as a driver for the co-location of the focal companies. The theory suggests that companies locate near major universities partly to gain access to internationally acclaimed leading researchers. In our case studies the location near the universities appears to be principally driven by inertia of the founders and the third-level skills pool that universities provide. Two of the companies spun off from Trinity College. The domicile of the founders and the fact that some of the founders retain their position in the university means that many start-up companies are located near the universities. In relation to the digital media companies, the location of two of the case study companies in Dublin is probably partly driven by the presence of the principle education and training colleges (and general agglomeration effects) and the Government's decision to develop and promote the Digital Hub in Dublin as the country's centre for digital media activity (see also section 5.7)

The research points to a number of general observations regarding the linking of knowledge bases to the geography of innovation processes. First, some stages in the innovation trajectory are conducted by researchers in a single research group. Moodysson *et al*. have equated this, in some places, with local collaboration. It is however important not to confuse local collaboration with in-house research. In the latter cases companies are simply not collaborating and depend principally on in-house and public, often codified, sources of knowledge. This introduces a second observation regarding the geography of knowledge flow in innovation processes. As we did in our case studies, *it is important to distinguish between the collaborative actors and sources of knowledge, and consider their geography separately. Although there is large overlap, this overlap is far from total.*

5.4 Organisation of Knowledge Communities and Central Occupational Group

5.4.1 Occupational Groups

Each industry has quite different occupational groups within it, although the composition of occupational groups varies relatively little across the firms within each sector.

The primary different sectors and different occupational groups involved in the biotech industry are:

- Academic – research scientists working in the relevant scientific areas and located primarily within universities;
- Clinical – medical practitioner/ researchers whose interest is in the clinical applications of new treatments and/or the understanding of particular diseases;
- Specialised technical services - specialised contract organisations working in the areas of toxicology, manufacturing antibodies, clinical trials, and so on. Presumably the main occupational community here includes a heavy proportion of lab technicians, although it is telling that this never becomes visible or relevant.

Each involves a different model of organisation and occupational community.

The dominant occupational group within digital media is that of 'animators'. However, this broad heading encompasses a variety of different roles. The main activities and roles are:

- Design animators and modellers (modellers for 3D animation only). These are responsible for the look and feel of the show (during the development and pre-production phase)
- Back-ground artist (responsible for designing the backgrounds) (during the development and pre-production phase)
- Story boarders (responsible for developing a long comic of an entire episode). This is done by animators as well, but the design element of the activity is already reduced (this is part of the pre-production stage)
- Layout
- Production stage animation. This is part of the production stage and is done by animators. Compared to design animation this is the less creative activity of populating the template. If a company does the actual production in house, they require a large group of animators. However, this work is often outsourced (in the cases of the companies discussed here, to, Malaysia, the Philippines and South Korea and Canada).

On top of these activities you have a range of other activities conducted by other specialized staff. At the pre-production stage you have voice recorder(s) (technical staff that are responsible for recording the voices of artists); at the end of the trajectory you need a sound engineer, a person that puts the animatics together (full length story board with text voice and characters), and a lighting person. Furthermore, a number of editors are required for editing the various takes and retakes at various stages.

Finally, all these people need to be directed and coordinated. Apart from the director who received inputs from a range of specialized directors (art director; animation director, an assistant director; sometimes a light director) this requires a producer and a production manager. Some of these are specialized in one of the skills mentioned above. Elsewhere in the production network, there are other occupations. The interaction with the broadcast sector is particularly important in this regard.

More telling than the actual occupational composition of each sector is that the 'system of professions' (Abbott, 1988) and the boundaries of different occupations is more fungible and less certain in digital media than in biotechnology. Most of the diverse roles in digital media (with the exception of the more specific technical specialisations) fall within the occupation of 'animation', even though careers will develop into different combinations of these different roles and individuals will specialise over time in particular activities. Furthermore, some people will take various roles during the project, further blurring any clear divisions between these roles or their formation into distinct occupations.

Biotech is composed of a variety of long-established professions, including doctors, biochemists and research scientists from other disciplines, and relatively clearly

defined associate professional occupations, such as lab technicians. The boundaries around some of these occupations are among the strongest of any profession with strong structures of self-regulation and management of entry to the profession among both doctors and scientists. The profession of 'animation' is much less institutionalized than these occupations, and boundaries around the profession are much less closely regulated.

In digital media, occupation is shaped as much by career path as by initial educational qualification, unlike medicine and biotech where formal qualifications are critical to access to particular occupational statuses – and are enforced as such by both state/law and professions themselves. In digital media, entry is largely (now) through formal education – although not universally – but occupation after that is determined more by career path and experience. A career as 'art director' develops through ongoing work experience in various projects, rather than through formal structures of career advancement and certification that lead to a well defined career path for 'art directors'. For example, in KDub (case 6), the senior people are keen to turn their relatively informal roles (one is predominantly creative, one predominantly produces and one is the art director) into more structured roles but it has not happened. It is also the case that there are a greater variety of pathways into the occupational structure of animation through, for example, media (arts degrees etc), business side of the industry, and the technical/electronic specializations.

5.4.2 Heterarchical and Hierarchical Knowledge Flows

In both industries, the innovation process is deeply uncertain – there are examples in all cases of ways in which the product itself changed, often quite substantially between the basic research or basic design and the final product. The production trajectories in each industry are open-ended and each industry displays a need for diverse sets of inputs into the process.

In each case, therefore, actors need to make judgments about the future development of technology and/or culture and to make decisions based on their interpretation of the best strategy within those changing contexts. Professional, social and cultural location affect how people in the process interpret these trajectories and make decisions as to strategies within them. This is not just a matter of people pursuing self interest, but of people possessing and drawing upon different 'rationalities' that are themselves shaped by people's location within the social world of each industry and the professions, sub-sectors, firms, regions and all the other elements that constitute those socio-spatial worlds.

Firms in both industries rely heavily on networking with partners to put together the innovations that are at the heart of these projects, and to bring those innovations into concrete form. This involves a networking together of different occupational groups and 'epistemic communities', as well as of different firms. It is impossible to conceive of these firms bringing these projects to fruition without a serious engagement with extensive networks of partners. This raises the question of how the knowledge flows from these diverse sources are integrated within the production and innovation process of the project.

The first candidate for providing such 'organisational integration' (Lazonick, 1996) is the firm itself. The structure of the company seems stronger in biotech, particularly since employment relations there emphasise greater permanence than in digital media where the freelance model is more widespread. In digital media the project is more clearly the central organizing unit. Therefore in biotech, networking beings together much more discrete and distinct firms, occupations and even, to some extent, social worlds (academia/ scientific, biochemistry, clinical/ medical, etc). In digital media, there are fewer such boundaries, with the industry defined by a broader technical community around the core organizing idea of art and design, and a highly mobile labour force.

Nonetheless, there is clearly in each case a core group within a firm that acts to manage the production and innovation processes. What has shifted historically is that the work of this core group is increasingly to integrate diverse inputs and knowledge flows from outside the firm rather than to coordinate the activities within the firm's boundaries. The work of developing the biochemical or cultural product of the companies is intertwined with the work of managing these diverse relationships, in both sectors.

The question then becomes how the different firms carry out this work of development and integration – how are the diverse inputs reconciled within the project? Here we see quite different modes of integration within firms, with extensive differences across sectors also.

As noted above, in digital media the core discipline of animation encompasses a variety of roles within a single professional identity. Each of the media firms in this study was organized around a core group that made the key internal decisions and managed the external relationships. This was most concentrated in KilAnim (case 5) where a single individual provided a 'personalized' system of organisational integration. However, this was generating problems with over-commitment and lack of delegation that suggested that this model quite quickly runs up against limits of scale. In the animation firm DubAnim (case 4), a closely knit core group provides this integration, with a fairly flexible internal division of roles. At KDub (case 6) too there is an artistic core that makes these key decisions, as KDub is in many respects a 'design house' that focuses on pre-production.

Interestingly, this structure is partly made possible by the digital media companies 'externalising' the business/ marketing side by taking on a (typically more experienced and well networked) co-producer who is stronger on that side. While it is not clear how central these co-producers are to the process, there is some evidence of information feeding back in through these networks (e.g. one of the companies was pushed to change the age bracket they were aiming at as they had the programme wrongly calibrated for the age of the children that might watch it).

In biotech, the task of integration is somewhat different as the communities of knowledge being networked together have more established professional identities, stronger organizational boundaries and more explicit structures of regulation. Without the incorporation of different roles within an all-encompassing identity like 'animation', biotech firms more explicitly face the integration of differing 'heterarchical logics' (Girard and Stark, 2002) within projects. FoodGen's (case 2)

mode of integration of diverse knowledge flows is perhaps closest to that of the media firms. The company is organized around a close knit core group. The group has a strong disciplinary core but with commercial commitments that is partly rooted in ties to agricultural community and industry. There is some heterarchy within the team through the fusing of disciplines within the core team. This is reinforced by the socialization of the core team, at least partly through the supervisor relationship between one of the team and the others during their PhD research.

TabPharma (case 3) is somewhat unusual as it is focused primarily on the realization of the IP and is more separated from the research community than the other biotech firms. Nonetheless, they continue to maintain ties with a wide range of research scientists and university laboratories. Most interesting is Biophar (case 1). This company has the clearest formal organizational hierarchy with strong roles for a scientific advisory board, overall board, senior officers, and so on. However, as the case study shows, there is also much more explicit discussion of the varying logics at work (clinical, biochemical, commercial) and the attempt to reconcile them is more open as it extends beyond a core group.

We should not, therefore, assume that because more formally hierarchical structures exist in a firm (or sector) that knowledge flows themselves are more hierarchical. In effect, biotech firms like Biophar deal with diverse heterarchical knowledge flows more explicitly through hierarchical structures – decisions made within these structures ultimately adjudicate these sometimes competing knowledge flows. However, there is also hierarchy in the other firms – including animation where a core group of elite designers makes most of the key decisions, in consultation/ negotiation/ agreement with key partners (co-producers, broadcasters etc). However, this is not organized through occupations or formal mechanisms and therefore it is less clearly heterarchical or hierarchical.

In both cases, heterarchy is resolved through hierarchy – but not Weberian hierarchy where key ideas come from the centre and are then communicated outwards in clearly defined form. Instead, while many ideas come from the centre they are largely communicated in basic outline terms with then significant input from 'below' or 'outside'. These inputs may however be contradictory and, in any case, need to be integrated in some way. The final decision returns then to the core group – whether that is personal (KilAnim in case 5), core group (FoodGen in case 5, KDub in case 6, DubAnim in case 4), or advisory boards and senior managers (Biophar in case 1).

External networks are a significant source of diversity in knowledge flows – and therefore of heterarchy within firms. However there are also important sources of hierarchy in external networks. The firms in this study (in both sectors) are involved in relations with a series of specialized suppliers who provide fairly standardized services, implying a more subordinate relationship to the development firms we studied. However, this hierarchy is weakened by the fact that these suppliers are providing a service that is also quite specialized and at times must meet quite specific regulatory standards.

There are relations too with broadcasters and others who control distribution and market. For example, in animation, when a dispute arose in case 6 between the Canadian and Dublin teams over whether to develop the animation in 2D or 3D, it

was the preference of BBC, the major customer and distributor that settled the issue. The concentration of media has placed key distribution channels, such as BBC, at the centre of the design calculations and decisions for even smaller media companies. Given the weak role of the Irish national broadcaster in sponsoring animation projects, its influence is quite weak. This may have changed as TG4 (an Irish language station) increased its commissioning of projects, although there is no sign of this in our case studies.

5.4.3 Organisation of Knowledge Communities

In our study of Biophar (case 1), we showed that while Biophar is carrying out the technological work of turning science into drug, this work involves it in the socio-spatial work of developing and maintaining relationships. Researchers must be networked into a diverse academic community, of which they are typically a part (at least at first). They must negotiate with clinical researchers whose professionally mediated access to, and control of, patient flows and disease data is an essential element of their negotiating power. This is of course mediated by the professional demands and responsibilities of doctors who retain the primary responsibility for patient welfare. The individual clinical researcher remains a vital gateway to that patient population. *The relative importance of these communities ebbs and flows over the course of a project with the academic community being most important in the initial stages but waning as development becomes more crucial.*

Biophar's case is perhaps the clearest example of what is a general pattern across the two sectors – the ebb and flow and shifting character of networks across the innovation process. Generally, we see that projects tend to be networked in two main directions, with one dominating at the earlier stage and the other at the later stages. Of course, within a firm at any given time there are likely to be diverse networks linked to multiple projects. This pattern holds across both sectors, although organized quite differently in each.

The first set of networks are into communities of innovation and predominate early in the project. In biotech these are largely into academia and other research networks, while in digital media these are in to the artistic and cultural world. While in biotech this involves accessing a set of high status institutions, in media it can involve the high status world of high culture but also (and increasingly) the world of popular culture. In both cases, however, innovation remains rooted in an engagement with a community that involves accessing diverse sources of knowledge through decentralized networks, loosely defined ties, and quasi-public spaces – the world of researchers in biotech and of artists, 'creatives' and designers in media. *In both cases public spaces – although differently organized – are crucial to innovation* (Lester and Piore, 2004).

Later in the innovation process networks shift primarily to specialized services of realization – in the case of biotech involving testing, 'humanising' and manufacturing and in the case of animation final production, editing, and more. These organisations exist largely in a 'merchant' relationship to biotech firms rather than the complex relationships of 'co-produced' research that characterise ties to research and clinical scientists. Different 'services' vary in how separable they are from development and

innovation process but generally there is a fairly clear interface and the desire is to access specialized pools of skills without having to deal with the complexities of work organisation and labour markets. However, even in these more standardized kinds of relationships, scientific know-how and knowledge sharing still matters. For example, case study 3 (TabPharm) shows that even in the work of testing and formulation close ties to universities or others with the craft skills of lab work are important. Nonetheless, the type of networking here involves more distant ties and is closer to what Sturgeon (2002) calls 'modular production networks'.

Despite their apparently more idiosyncratic artistic elements, there are networks in the later tasks of final production in animation that are also relatively standardized. Much of this 'joining-the-dots' work is outsourced to much cheaper locations around the world. However, complexities in knowledge flow remain – and both of the companies that had outsourced such work had employed their own production supervisor to work on location with the contractor.

Networking varies over time during the project. The company's (or project team's) reach broadens at first into various public spaces or innovation communities, it then narrows around the project team where the firm is 'adding value' to the externally sourced intellectual property, and then moves out into a broader range of specialized contractors involved in fulfilment and production rather than the innovation and design itself.

As we noted above, this is at the level of the project and at any given time a firm may have a diverse set of networks, aggregating across multiple projects. There is very little discussion in the interviews about how knowledge travels across projects within firms, although it clearly does travel with employees' experience. However, we don't know-how much – or how little - networking or synergies across projects exists. While there is little evidence of it in our interviews this may be a methodological artifact of focusing on the project as unit of analysis.

While some networks are 'open' while others are more tightly controlled, innovation seems to be driven primarily by engagement with public spaces and 'communities' where information sharing is relatively open. Indeed a number of observers of innovation in the US have documented a shift from an innovation system dominated by the corporate labs of large firms to an 'open system' of public agencies, universities and networks of small firms (Mowery, 2009; Block and Keller, 2008). Our results are in consistent with these findings – while also finding important differences across firms and, particularly, across sectors in how they engage with these open systems of innovation.

Of course, intellectual property matters and there is an ongoing tension between the open system of innovation and the closure implied by intellectual property. In almost all the cases we studied, the start of the innovation process was an existing piece of intellectual property (a book, a patented technology, and so on) or a discrete idea that could be turned into intellectual property. But the innovators engaged widely in broader communities and discussed their ideas with others (e.g. at conferences or on blogs) and drew on others' ideas (e.g. through literature searches and close observation of new cultural productions). The production of IP in a single organisation was profoundly entangled with the public spaces of dialogue and

communication about scientific and artistic innovation in general. Pre-production work in biotech and animation is largely public or quasi-public in nature, therefore.

Furthermore, IP is never completely fixed – even if a particular piece of IP is defined, the thinking and research in that area continues to develop, and social relations in the innovation process may be affected by this (e.g. the continuing tensions between FirstPharm and TabPharma, case 3, in the 'technology space' they share).

5.5 The Organisation of Firms and Markets

As we have seen, each of these projects exists at the intersection of a series of sets of networks that change shape over time in ways that are reasonably predictable. Each also combines a variety of knowledge flows and rationalities within heterarchical organisational structures. *But each firm within which the project is located reconciles these networks and heterarchies in different ways*.

We have discussed these differences in some detail in the section on heterarchical and hierarchical knowledge flows above (5.4.2). But what drives these differences? The degree of integration of the core group appears crucial – if this group is cohesive and has a strong collective view on most issues, as well as incorporating different knowledge flows within the group itself, then the informal decision-making within the group will probably be sufficient to manage the diverse knowledge flows. That integration itself is linked to the broader pattern of formation of occupational communities and the social structures of innovation within which firms are founded. For example, in animation the core groups are bound by a common identity as animators – but this in turn is reinforced by the structures of socialisation in the courses at Ballyfermot, and in its alumni networks. In biotech, the socialisation into the scientific norms of the research community can play a critical role, and is reinforced by the ongoing ties to former supervisors, friends from postgraduate research and former colleagues.

What about the structural features of the firms themselves? Biotech firms tend to be older than animation firms – or, more strikingly, biotech projects tend to have much longer histories than those in animation. Each of the three biotech projects studied here is based on research that began 15 to 20 years ago, in most cases outside the company itself. However, this does not in itself appear to change the character of knowledge flows. It does seem to create a more sustained engagement with the world of research, with universities and seems likely to contribute to longer term employment relations and careers. On the other hand, despite these differences, the basic structures of networks and heterarchies within each sector remains. It also, as we will see, shapes financing needs.

Organisational scale matters, in that the larger firms (e.g Biophar) appear to be more formalized – although this may not apply within single projects. Nonetheless, there appear to be limits to organizational integration through a core group (e.g. the problems with lack of delegation at KilAnim (case 5). Again, the biotech sector appears more formalised but this may be as much due to regulation (and the need for documented, and documentable, knowledge flows) as to size and its informational demands.

But, as we have seen, the organisation of innovation within each firm and sector is most heavily influenced by the differing organisation of knowledge communities in the two sectors – the range, diversity and regulation of knowledge communities in each shaping in significant ways the internal organisation of firms and projects. An important element of those external knowledge communities that we have only briefly touched upon is the structure of the larger competitors and customers of the biotech and animation companies.

In each sector, it appears that it is individuals who are the market for the product – whether as patient or as viewer. However, for the companies the markets that matter are those intermediaries that control access to these final users. For animation companies, the broadcast companies loom largest in this respect. They exercise a close influence in designing the basic shape of the programme being developed, as the content has a close tie to their core asset – their programming content. From the earliest stages, companies like BBC and Nickelodeon are shaping innovation in digital media.

In biotech, this innovation proceeds for a much longer period of time outside the larger corporate pharmaceutical structures. The long lead time of biotech development and uncertain outcomes help to explain why corporations do not exercise close direct control over companies at this point. However, the trajectory of biotech research at the more general level will be deeply influenced by the demand of healthcare professionals and organisations and by the decisions of public funders (such as the US National Institute of Health) and private funders (such as venture capital).

Big pharma, on the other hand, don't control distribution channels and company name/branding plays a limited role. In principle any small Biotech firm can bring its product through clinical trials and start selling it. The clinical trials require regulatory and organisational knowledge but this can be in-sourced (scientific advisory board) and out-sourced (to the CROs). However, there are other ways that customers exercise influence. Selling biotech products requires a huge sales and marketing force (visiting doctors and hospitals etc). The huge costs often lead smaller biotech companies to license their products to big pharma or to sell the company to these larger companies. Much as in many areas of information and communication technology, the research system has been increasingly externalised outside of the big pharma companies and those companies now spend increasing amounts of resources scanning for potential licensing or acquisition opportunities.

Ironically, it may well be that in biotech there is less highly concentrated control over intellectual property at this stage as research activity remains relatively decentralized while media ownership and distribution has become increasingly concentrated. Networking into the core intellectual ideas of media may involve greater engagement with corporate organizations at an earlier stage than in biotech, where academic research remains central and relatively widely available.

5.6 Institutional Context

This section discusses and compares the role of the institutional context of the innovation processes in the two industries. It considers, in turn, the associational networks, forms of regulation and sources of finance

5.6.1 Associational Networks

There is relatively little evidence that industry and trade associations are important to innovation in firms, although the networks formed through them seem to be more important in the early days of a firm's growth. Such associational networks may be more important for newcomers or outsiders in gaining access to the local scene than for established firms. Associational networks may also be more important for other activities, other than innovation.

Firms do appear to benefit, however, from integration into a social world of the industry itself. This is partly linked to the specific inter-firm networks that firms have but – and especially in the earlier and/or more innovation centred part of projects – also consists of a loose web of ties that people within the project have to others in the industry. In biotech that 'scene' is largely centred on the research community and in particular on universities. In digital media it is a looser network of people working in the area but also the broader artistic and design community – often organised more informally (e.g. through animation blogs and other sources of 'open' online community). These networks often fuse local and international ties.

5.6.2 Forms of Regulation

More formal forms of external influence play an important role. In particular, the external regulation of biotechnology is much stronger than in digital media. Although there are clear broadcast regulations around, for example, content of animation for children, this does not seem to loom large in the animation projects studied here. In biotechnology, however, not only the content of the product but the production and innovation process itself is closely regulated.

Only certain actors are legitimately allowed to carry out particular tasks (eg test processes must be the responsibility of clinicians and a variety of other processes are only to be carried out by specific actors). While scientific innovation is, in theory, 'open, in practice access to the relevant facilities and opportunities for learning and experimentation is closely controlled through educational and professional institutions. The procedures of work itself are also designated in specific ways - and in some cases by law. This regulatory regime and the interests of existing high status medical and scientific professions have become increasingly intertwined.

The cultural politics of media and broadcasting in different societies undoubtedly plays a role in innovation in digital media. But in the cases we study that is largely mediated through the influence of broadcasters on the early stages of the innovation process, where they play a significant (and largely taken for granted) role in shaping the content of the animations. It is clear, however, that a mixture of market access, cultural and language connections and regulatory regimes place Irish digital media fairly firmly within the Anglo-American media worlds.

5.6.3 Finance

A further, crucial influence is the structure of financing for both industries. In each sector, state agencies have played important roles in early stage financing through tax incentives but also through direct funding and loans from agencies such as Enterprise Ireland and the Irish Film Board. This funding has in some cases been crucial in allowing firms to develop their projects to the point where they are viable prospects for external investors. Research funding in biotech serves as a very substantial public subsidy of innovation in the industry (See also Lazonick and Tulum, 2008).

Such external investors are crucial in both sectors, given the relatively long lead times before developed products earn revenues, particularly in biotechnology. Furthermore, in biotech, in particular, the possibilities for funding product development out of service work (as many software companies do) is not a practical option. *But while external investment is crucial it takes a different form in each sector.*

In biotech, while research and development is costly, it is often heavily subsidised through public research funding. However, the last stages of clinical trials are extremely costly. Few smaller companies are able to break into the ranks of big pharma and most seek to licence their technologies to the "big pharma" companies or to sell the company itself to one of these companies. Big pharma also becomes involved at a relatively late stage, whereas in the animation companies the project does not really start before the big commissioning broadcaster or distribution company get involved. Here, as we have seen, broadcasters play an early role in shaping content. In two of the cases we have examined, the small animation companies have tended to take on a co-partner who acts as intermediary in these negotiations around content and finance, typically someone with extensive industry experience and networks.

While our study has focused on innovation among smaller companies, it also indirectly sheds light on the increasingly important 'innovation by acquisition' strategies of the major oligopolistic companies in media and biotech. The flip side of the 'open innovation' system where networks of small firms and public research centres generate an increasing share of innovations, is the persistent financial and distributive power of the largest – and increasingly concentrated – firms. This financial and market power becomes more crucial to these firms as the centre of innovation moves towards the kinds of networks we have identified in this study. The balance of power shifts among the larger and smaller firms in the industry, with each drawing on different assets – however, the outcomes of these changed inter-firm negotiations and the impact on innovation is not clear from our case studies.

5.7 Relative Importance of the Region/ Ireland

Based on the material presented thus far and before looking into the implications for digital ecosystems it is helpful to make some summary comments on the role/salience of the regional/national (Ireland) ecosystem in the innovation processes. The

comments below should be interpreted from the perspective of the Irish focal companies in the case studies.

In none of the biotech cases does the region or Ireland play a significant role in the innovation trajectories. In all cases nearly all the main partners and other sources of knowledge are located outside Ireland. Nearly all the main markets are located outside Ireland as well. The picture regarding the local labour market is somewhat mixed. From the perspective of Biophar, a company that requires very highly skilled and educated staff, the regional skills base is weakly developed and this company relies strongly on the international labour market. For FoodGen (case 2) on the other hand, a company with relatively lower skills and qualification requirements, the local universities and the regional pool of skilled labour are important assets and the company is able to recruit most of its staff from within the region

Because most of the end-user markets are abroad, the most important regulatory institutions (e.g. the US Food and Drug Administration) are located abroad as well. To the extent that the companies need to deal with Irish regulatory authorities (e.g. Irish Medicines Board), these are located near the companies in Dublin but the focal companies have very limited contact with these institutions.

The regional/national biotechnology cluster and sectoral system of innovation are still very much in their infancy and the companies derive few benefits from them. The companies are all relatively weakly embedded in local networks of formal and semi-formal associations. The industrial promotion agencies have developed biotech-specific web-sites and networking tools, but the companies and their staff make very little use of these. In two cases, Biophar and FoodGen, the region had of course functioned as the breeding ground for the leading scientists who founded the companies. In this regard these firms have benefited strongly from the Irish government policy in the area of science, technology and innovation, notably the growing level of funding of third level education and the funding of research in biotech. The companies did receive some funding from the local industrial promotion agency (Enterprise Ireland) or Government Departments. Although in one case (FoodGen) this was instrumental in kick-starting the development of the project, in the grand scheme of things the funding is negligible.

The local region and Ireland play a somewhat greater role in the innovation trajectories of the animation companies, but the role is limited here also. Nearly all of the main partners and other sources of knowledge are located outside Ireland. Although in one case one of the initial customers was local, all projects target international markets and the main customers are located outside Ireland. The Irish broadcasters have a poor history of commissioning children's animation series. The main sources of knowledge are global (partners and international events) or virtual (international Internet sites, Internet forums, etc). The potential sites for 'buzz' in Ireland are limited and do not appear to be salient for knowledge flow. The Irish community may well constitute a vehicle for intentional and unintentional knowledge flow, particularly for know-who type knowledge, but the most important sites for exchange are international and virtual, rather than local. Even the two firms located in or near the Digital Hub, the main concentration of animation and digital media companies in Dublin, did not benefit from networking with other companies there.

The third-level training and education infrastructure does provide an important source of skilled labour, but the skills base is limited and all companies rely heavily on international recruitment. For recruitment a Dublin location offers some advantages over a location outside the capital because the pool of skilled labour is greater and because it offers a more attractive place to live for international staff. The third-level education sector was also important as a source of new company formation with all focal companies being founded by former class mates from the Ballyfermot College. The final year projects appear to have been particularly valuable through forging collaborative linkages and a first step in the formation of the companies.

Compared to the biotech companies, the animation companies appear more strongly embedded in networks of formal and semi-formal association. Although the more relevant ones are again global, the animation firms are connected to more local associations than the biotech firms. *Animation Ireland,* the web-site maintained by Enterprise Ireland also appears to be more intensively used than its equivalent in the biotechnology sector. Although the third level institutions were an important source of skilled labour and new companies, the animation firms maintained few links with the third level institutions.

A location in Ireland is beneficial primarily because of the available fiscal and financial incentives. Although the main sources of finance are global, some of the projects would not even have gone into development without the loans/grants from the local institutions, while the fiscal incentives, notably Section 481 tax credits, are a crucial part of the fiscal/financial model.[3]

[3] Section 481 tax credits can provide a benefit of up to 28 per cent of eligible Irish expenditure. The Irish Film Board provides development loans and grants for early project development. The Broadcasting Commission of Ireland provides development funding under the 'Sound and Vision' fund. This fund was set up to fund 'public service broadcasting' related projects.

6 IMPLICATIONS FOR DIGITAL ECOSYSTEMS

WP11 of the OPAALS project (phase 2) focuses on bridging the gap between digital ecosystems research and regional development and innovation in the knowledge economy. The objective was to bring together the theoretical deliberations surrounding the digital ecosystems concept and the practical concerns of regional development policy. Towards this, we have investigated the socio-spatial foundations of knowledge flow and innovation. Chapter 5 of this deliverable has provided critical insights into the innovation processes within and between companies and the spatial configuration of these processes, notably the extent to which these processes are regionally bounded. These findings have important implications for the structure and possible functions of digital ecosystems in the biotech and digital media sectors (as well as other sectors characterised by similar knowledge bases).

A Digital Ecosystem (DE) is a self-organising digital infrastructure aimed at creating a digital environment for networked organizations that supports co-operation, knowledge sharing, the development of open and adaptive technologies and evolutionary business models (Nachira et al., 2007). A DE provides structures of communication and collaboration that can facilitate collective learning, knowledge flow and innovation across SMEs and other actors.

It is envisaged that DEs can promote competitiveness of SMEs and stimulate regional development processes. A DE has the potential to promote regional development in different ways. First, it may facilitate efficient and secure communication and knowledge flow between regional actors (partners) collaborating in a specific innovation project (including between individuals in the same institution). In this instance a DE can play an important role in project management and related knowledge flow, similar to existing proprietary web-based systems. Secondly a DE could act as a more general communication tool and knowledge resource, connecting all regional players in a specific industry or field (irrespective of whether or not these actors are partners in a specific innovation project). Two further channels through which DEs can promote regional development involve the DEs playing the same role and providing the same advantages as outlined above not just for regional actors but for all actors globally, irrespective of their location. This would not necessarily facilitate regional knowledge flows, but would enhance the competitiveness of firms in the region by linking them more efficiently and securely to their external innovation environment.

Table 6.1. Different ways in which DEs may promote regional development and competitiveness of SMEs

Route 1	Facilitate efficient, secure and democratic communication and knowledge flow between regional actors who are collaborating in a specific innovation project
Route 2	Act as an efficient, secure and democratic communication tool and knowledge resource, connect all regional players, irrespective of whether they are partners in a specific innovation project or not
Route 3	As in Route 1, but now for all actors, irrespective of location
Route 4	As in Route 2, but now for all actors, irrespective of location

The case studies of the biotechnology and digital media industry suggest that, largely irrespective of the knowledge base, the innovation projects of companies in the Dublin area involve very little collaboration with other regional and even national actors. This may, of course, be partly due to the relatively small size of the sectors in Ireland. However, the case study also suggests that partner choice in general is relatively insensitive to distance decay. Therefore, in the Irish biotechnology and digital media industries, a DE is unlikely to play a significant role in promoting regional development via route one. A DE can of course play an important role in facilitating sporadic examples of innovation projects that involve local collaboration, but in the short to medium term this is unlikely to have a significant impact on overall regional development and the competitiveness of the two industries in the region.

A DE could stimulate regional development and the competitiveness of the two industries in Ireland by facilitating efficient and secure communication and knowledge flow between all actors involved in a specific innovation project, irrespective of their location (Route three). The case studies found some evidence of the use of propriety project management systems to organise knowledge flow with external partners (see below) and most interviewees would welcome the development of similar applications as part of a DE system (see below). The key question relates to implementation or adoption of the DE system. A DE can only be effective at a global level if all actors in the innovation project adopt the DE. However, DE initiatives tend to be piloted and promoted on a regional basis. This creates a "chicken-and-egg" situation. Due to resource constraints, DEs tend to be piloted on a regional basis. But actors will only be fully convinced about the benefits of project management applications if they can be used on a global basis.

In the Irish context, a DE is more likely to stimulate regional development via Route two - by acting as a more general communication tool and knowledge resource, connecting all regional players in a specific industry or field (irrespective of whether or not these actors are partners in a specific innovation project). In this way, the DE would facilitate a type of Open Knowledge Space. The fact that, the Irish companies in the two industries rely largely on global sources of knowledge for individual innovation projects does not mean that the DE has a limited role here. The DE could act as an important regional *resource of knowledge*. It could, inter alia, allow firms and individuals in the region to exchange knowledge; allow individual actors to advertise their services; provide information about initiatives of industrial promotion agencies; allow individual actors to communicate recent developments in a specific field; provide a brokerage facility for local venture capital and other sources of finance; provide employment services; provide a vehicle for regional-level associations to advertise their services and connect regional actors to various knowledge resources.

Some of these knowledge sources may be global. For example a regionally organised DE could provide links to global news sources, e-journals, global directories, etc. Here the distinction between a regional digital environment and a global digital environment (Route 4) becomes blurred. The main distinction is that the regional digital ecosystem is organised and structured primarily to facilitate knowledge flow both to and between regional actors and to promote the competitiveness of the regional industry.

The regional development agencies and industry associations have already developed industry specific web-sites that aim to act as a knowledge resource. The open knowledge space and DE we envisage would have a greater and rather different functionality. First of all, the underlying philosophy of peer-to-peer interaction and democracy would allow all regional actors to provide content. The active involvement of the regional actors is, in itself, likely to increase the intensity of the knowledge flow in the DE.

Rather than simply providing data on companies and actors, primarily aimed at generating collaborative innovation projects, the DE adds a strong assistance/support functionality. Companies and individual actors provide information about their knowledge assets and requirements. One of the central questions becomes *"what knowledge that could be of value to me do you have, and are you willing to share?"* This may be particularly beneficial, to young companies and new actors, but not exclusively so.

The DE should provide a multi-level data/communication structure. Some levels are shared by all firms and individual actors while others are only accessible to smaller groups. The different levels mediate knowledge and information with different levels of sensitivity, requiring different levels social proximity and trust.

The digital business ecosystem should involve the entire social world of the firms, linked to the specific inter-firm networks that firms have but also to the loose web of ties that people within innovation projects share with others in the industry. Our research confirms that, although some innovation networks are more open then others, innovation seems to be driven strongly by engagement with public spaces and 'communities' where information sharing is relatively open. Innovation remains rooted in an engagement with a community that involves accessing diverse sources of knowledge through decentralized networks, loosely defined ties, and quasi-public spaces. Public spaces are crucial to innovation. Rather than merely facilitating knowledge flow and collaboration related to a specific innovation project, a DE becomes a new type of public space, facilitating 'interpretive action' (Lester and Piore, 2006).

This new public space facilitates both intentional knowledge flow and buzz. Although local communities do exist in both industries, currently the level of local buzz is limited. Local communities are buzzing globally rather than locally. *A well functioning DE would intensify the level of local buzz.* This will, of course, not happen in the absence of a certain level of social proximity and trust. The DE is not a substitute for face-to-face context but offers an additional (virtual) local space to intensify the level of local buzz.

The role or application of the DE will take different forms during the various stages of an innovation trajectory. Interpretative action and the public space are particularly important during the early stages of innovation projects. In later stages, it may be used primarily as a vehicle for project management between a select group of partners.

We have shown how processes of knowledge flow and innovation differ significantly from industry to industry. *Hence the specifics of a DE and the precise route via which*

it can contribute to regional development will also differ across industries. The research points to the importance of awareness of the range of actors and socio-spatial structures involved in innovation trajectories when developing a DE. Much of the literature on networks and knowledge flows either takes individuals and the networks between them as the only units of analysis or it look at the flows between firms, leaving the firms as 'black boxes' that simply act as receivers and transmitters of flows. However, this is a potentially serious error. First, to state it in negative terms, such an analysis risks ignoring many factors relating to firms, professions, occupational groups, technical and epistemic communities, social groups and so on, that may shape, impede or undermine knowledge flows - for example, it ignores the possibility that information may flow into a customer service department that would be vital to the development teams but that never reaches those teams because of internal organisational rivalries.

Second, put in positive terms, these analyses also ignore the many socio-spatial structures (the very same firms, professions, communities, social groups and so on) that may in fact be vital carriers of information through the industrial system. A DE that ignores these vital structures of information flow operates with one hand tied behind its back. In addition, there are likely to be many kinds of information flow - some will be 'open' to all, some will be 'closed' to particular actors and operate largely 'offline', while perhaps most will operate in a grey area between these two extremes. Without recognising the organisational and social structures that shape knowledge flows, we run the risk of designing technically excellent DEs that are not used by business actors - not for technical or usability reasons but for reasons of organisational politics and interests. In short, in order to understand sustainable DEs of SMEs and the contribution they could make to competitiveness of SMEs and regional development we need to understand in depth the processes of knowledge flow and innovation.

Based on the research findings, we can make some general suggestions regarding the implications for the biotech and digital media industries in Ireland. (The relevance of these suggestions will need to be validated during interviews with key-industry players and experts.) In the biotechnology sector, given the important knowledge generating role of the universities, one of the most valuable roles of a digital ecosystem in the biotechnology industry is to facilitate knowledge transfer from these universities and research institutions. Universities and their lead scientist would therefore be the most important players and potential catalysts in a DE organised on a regional basis. The role of clinicians with their crucial knowledge about unmet market needs is probably more important (from a DE perspective) than that of end-user (patient) associations. The digital ecosystem will mainly connect small and medium scale enterprises. The importance of formal education suggests that epistemic communities should be an important element in the structuring of a biotech DE. With venture capital being an essential element of the biotech eco-system, a DE may play an important venture capital brokerage role. Finally, industrial development agencies are important both as a source of funding and know who knowledge.

In relation to the Digital Media (animation) sector, the digital ecosystem connects small and medium scale enterprises and larger companies (broadcasters and distributors). Within the small animation companies the producers and development groups can potentially benefit strongly from know-who type knowledge that the DE

could provide. The more limited importance of formal education and fuzziness of the functions would suggest that the DE is best structured along the lines of communities of practice or technical communities, rather than epistemic communities. The role of educational institutions as a knowledge resource is limited but they do form an important part of a regional DE. Final year students could use it as a medium to show-case their work and attract first contracts/business. In addition, the DE could be used to connect and exploit alumni networks. Finally, given the prevalence of free-lance crew the DE could play an important role in employment search and recruitment. Finally, industrial development and other agencies are important, notably as a source of funding.

In both industries the current use of digital environments falls well short of the above. In the biotechnology industry the use is limited to the Internet, email and *Skype*. The Internet is used to access the academic literature, for identifying potential supplier/partners, for accessing subject/discipline specific forums and for recruitment purposes. Internally, the small biotech companies use server-based systems to file project-specific documents centrally and different groups of staff have access to specific folders. In the animation projects, Email, teleconferencing, *Skype*, and video conferencing are used intensively to communicate with the various project partners. All companies use, or are experimenting, with web-based inter-firm project management tools (*Basecamp, Hobsoft, MS SharePoint*). However, the systems do not operate satisfactorily. The Internet (*Google*, forums, blogs) is used to access know-who type knowledge, inspiration and for recruitment as well as communicating the project to the outside world (website and blog). The *regional* digital ecosystems for both industries are largely limited to the web-sites of the industrial development and sectoral promotion agencies that are not used extensively.

The majority of actors interviewed for the case studies appreciated the potential role that a digital ecosystem could play both as knowledge resource and as a collaborative, project management tool. In most cases companies pointed to the DEs role as a global scale collaborative (project management) tool (route 3). It is unlikely that a DE could support this in the short to medium term. Interviewees also pointed at trust issues that would need to be overcome before a DE system could be adopted.

The relevance of our ideas regarding the structure and possible functions of Digital Ecosystems will need to be validated in future research (including OPAALS phase III), notably interviews with key industry players and industry experts. In addition, future research can expand our knowledge regarding the use and structure of DEs by changing the unit of analysis. The current research looked at innovation *projects*. By doing so we were able to show that individual innovation projects of companies in the Dublin area involve very little collaboration with other regional actors and that a DE is unlikely to have a significant regional development impact if it is structured to facilitate communication between regional actors who are collaborating in a specific innovation project (as a project management tool). However, firms occasionally collaborate with local partners and, over time, these collaborations give rise to local networks. In addition, as discussed, local communities do exist. Social network analysis (with the firm and/or the individual as the unit of analysis) can provide valuable insights into the structure of these networks/communities and the related knowledge flows and provides additional ideas regarding the application of DEs as local knowledge resources (Route 2). In addition, social network analysis can provide

an important tool for identifying potential catalysts in the development of the digital ecosystems.

CASE STUDIES

7 CASE STUDY 1

DEVELOPMENT OF A BIOPHARMACEUTICAL AGAINST ACUTE INFLAMMATORY DISEASES – (BIOPHAR)

C1.1 OVERVIEW

This case study concerns the development of an anti-body based drug against acute inflammatory diseases such as sepsis, cardiac and kidney ischemia/reperfusion injuries and potentially other inflammatory diseases. Inflammatory diseases involve Toll Like Receptors (TLRs). These TLRs send the first signals to the immune system that trigger inflammatory immune responses. The TLRs are located on the outside of white blood cells. When a molecule from infectious organisms locks onto a TLR, the TLR activates inflammatory signals. This, in turn, triggers a response by adapter proteins in the cell. This process can be out of control leading to acute inflammatory diseases. One possible solution is to block the TLR with an antibody based drug. At the time of the research (2008) the project was in the hands of *Biophar*[4], an Irish owned dedicated biotechnology company located in Dublin. However, the basis for the innovation was laid in the mid-1990s and has involved many other actors.

For many years it was known that bacteria could trigger the immune system. But it was not clear what was recognising the bacteria in the first instance. Research groups in many universities and companies, involving different scientific disciplines such as biochemistry and immunology, were trying to unravel the processes involved. In 1996 the first of ten TLRs were identified as the missing link. The identification of each TLRs triggered research by many other research groups around the world into the function of the different TLRs, the signalling processes and the response in the cell.

The TLR involved in ischemia reperfusion injuries, TLR20, was first reported in January 1998 by GENX, a dedicated biotechnology company in Palo Alto. The company tried to get patents on the TLR but these were not granted. After this other laboratories around the world, including in Osaka and Seattle, started to work on it and by 2000 its function had been worked out.

Other research groups, again mainly in universities, started to look into how this new knowledge could be used to halt inflammatory processes. A group at Trondheim University successfully raised an antibody to block the TLR20 and was granted patents on the concept of targeting the TLR with an anybody. Other groups, including one in Munich developed their own antibodies (paying Trondheim for using the concept).

At this stage that Biophar got involved. Biophar is a spin-out from Trinity College Dublin, one of Ireland's leading academic institutions with a core focus on immunology research. In 2003 a foreign businessman with a science PhD and business experience in biotechnology contacted the industrial promotion agency with the idea of commercialising unexploited innovative projects or intellectual property in Ireland. He was introduced to a number of senior researchers. Three professors, in

[4] Biophar, TLR20, GENX and BIOP3 are fictive names.

Trinity College Dublin and NUI Maynooth, had complementary IP in the field of immunology. After realising that there was sufficient merit, the businessman and the three professors founded Biophar in 2004. Since 2004 the company has focussed on developing new drug candidates which function by inhibiting TLR pathways, exploiting the existing IP and academic expertise of the founders.

Drug BIOP3 did actually not exploit IP of the founders. It was simply identified as a commercial opportunity in the field of TLR. The scientific advisory board regularly discussed commercial opportunities, irrespective of whether the IP is in-house or not. One of the founders was a global leader in TLR research. Based on his knowledge of the field he suggested that TLR20 offers great opportunities for treating inflammatory diseases. A 2-months period of literature review, clinical review, a search for available compounds and an IP review confirmed the potential of TLR20 for targeting at least 5 different diseases. During this process the company consulted a range of clinicians (often with their own research groups) with expertise in certain diseases to get their opinion. On the basis of this a drug development project was established.

This started with the identification of specific compounds that could have an effect on the TLR20. The company secured about 8 patents around the concept of targeting the TLR20 with an antibody (from Trondheim University) and around different antibodies (from Trondheim and other European universities, including one in Munich).

The project now enters the next stage – further R&D into antibody-based drugs for specific indications. It represents the transition from drug discovery to drug development. At this stage the drug is tested *in vitro* and in animal models for different diseases. Biophar conducted the research for one model. Most of the research for the other models was done by the external clinicians and their research groups that had been part of the initial consultation process. These were selected on the basis of their expertise in specific diseases. Research models for the first two diseases did not prove efficacy. However, subsequent research suggested that the antibody worked successfully in three other models and the company successfully filed patent aplications for those compounds on the particular diseases, including ischemia/reperfusion injuries. The concept and the hypothesis had now been proven in models and Biophar was about 2.5 years into the project.

The project now entered the pre clinical validation phase. At this stage, before a drug candidate can be tested on humans, it is subjected to further tests, including animal testing to determine its toxicity and epitope mapping. This was done by external consultants (toxicologists). At the same time the company needed to further develop the actual antibody. Any antibody needs to be humanised before it can be administered to humans without side-effects. For this Biophar contracted a company in Cambridge that had the necessary capability and IP. Developing a humanised antibody took seven month. In addition the antibody needed to be manufactured at a sufficient scale to feed the clinical trials. For this Biophar contracted another company in Europe or US.

At the time of the research Biophar was developing its toxicology package and manufacturing package. It was also starting the preparation of the actual Phase I clinical trials. The innovation became more and more process and regulation driven.

A single development manager at Biophar selects and organises the contact with relevant external actors, including regulatory authorities, hospitals, clinicians, contract research organisations.

Most of the actual trials and initial data analysis will be conducted by clinical research organisations (CROs). The selection of the CROs will depend on where the clinical trials will take place which, in turn, is driven by a range of issues including, the disease target, regulatory authorities, cost considerations etc. At the time of interviews the company was considering the UK, Germany and Australia. The actual research will involve little co-operation between the CRO and Biophar. Biophar will instruct a CRO and the CRO will communicate the results. In preparation for the trials and during the trials Biophar will consult and deal with a range of clinicians and hospitals to ask their advise regarding conducting the trials and interpreting the results.

Biophar plans to bring the product up to phase III clinical trials. These trials involve thousands of human subjects and require a large amount of financial capital. The likely scenario is for the venture capitalist to exit at this point via an initial public offering or a trade sale to one of the large “big pharma firms”.

We distinguish five different stages in the innovation trajectory.

1) Research to understand the immune system. The identification of TLRs and their function.
2) Research into how this knowledge can be used to halt inflammatory diseases. Leading to the idea of using compounds that block TLR20.
3) Further R&D into antibody-based drugs for specific indications
4) Pre-clinical validation
5) Clinical Trials

C1.2 PATTERNS OF KNOWLEDGE FLOW AND INNOVATION

C1.2.1 Type of Actors and their Location

Research into the TLRs and their functions is very much the terrain of academic research departments. However, the TLR20 was first reported by DNAX, a dedicated biotechnology company in Palo Alto acquired by Schering Plough. The research into the actual functions of TLR20, the signalling processes and the response in the cell mainly involved university research groups. Several research groups around the world, including one in Osaka and Seattle, were involved. All these groups, sometimes working individually but often in collaboration, contributed small innovations that constituted pieces of the puzzle. Typically, individual groups are headed by an academic principal investigator who directs a varying number of post-doctoral and post-graduate scholars. The subsequent, research into how this new knowledge could be used to halt inflammatory processes was again conducted mainly by academic research groups. A group at Trondheim University successfully raised an antibody to block the TLR20 and was granted patents on the concept of targeting the TLR with an anybody. Other groups, including one in Munich developed there own antibodies.

In the next stage - further R&D into antibody-based drugs for specific indications - the company Biophar takes control of the innovation project. The company acquired the relevant IP from the previous actors who cease to be involved. In vitro and animal studies for one of the models were conducted by the company itself. Research for the other models was done by the external clinicians and their research groups. All these groups were located in Europe: two in the UK, one in The Netherlands, one in France and one in Ireland. All these groups worked independently on a particular model and communicate the results to Biophar. Within Biophar the *in vitro* and animal studies are conducted by scientists organised in three groups – the molecular biology group, the assay development group and the in vivo pharmacology group. The groups are headed by the group leaders who direct two or three technicians. Although the group leaders have a somewhat general understanding of the overall project, the groups have specific expertise and conduct specific tasks in the project. On a daily basis the groups typically work independently from each other. The three group leaders report the research findings back in weekly or bi-weekly project team meetings, headed by a project leader.

Next, during the pre-clinical validation stage, nearly all of the actual research and tests are contracted-out to specialised consultants or companies. Toxicology studies were contracted out to a UK-based toxicologist while another company outside Ireland was responsible for the epitope mapping. The humanisation of the antibody was conducted by a company in Cambridge with the specific expertise. Finally, the manufacturing of the antibody was again contracted to a company outside Ireland, either in Europe or the US. The work tends to be technical and specialised (but not product specific) and is strongly driven by regulations. It is not within the core-competence of Biophar. The transaction involves minimal co-operation. Biophar instructs what they want to have done and the contractor delivers on a “fee-for-service” basis. The co-ordination of the activities is virtually all done by two Biophar staff member, the VP of Pharmaceutical Development and, to a lesser extent, the Project Leader

At the time of the research Biophar was starting the preparations for the Phase I clinical trials. Most of the actual trials and initial data analysis will be conducted by clinical research organisations (CROs). The selection of the CROs will depend on where the clinical trials will take place which, in turn, is driven by a range of issues including, the disease target, regulatory authorities, cost considerations etc. At the time of research the company was considering the UK, Germany and Australia. The actual research will involve little co-operation between the CRO and Biophar. Biophar will instruct a CRO and the CRO will communicate the results. In preparation for the trials and during the trials Biophar will consult and deal with a range of clinicians and hospitals to ask their advise regarding conducting the trials and interpreting the results.

In summary, during the first two stages of the innovation trajectory, the main actors were academic research departments in multiple locations around the world, often collaborating in global research networks. During the third phase, - further R&D into drugs for specific indications – an Irish company Biophar takes control of the innovation project. The company has a “semi-virtual” business model whereby some of the research is conducted in-house and some of it externally. Like playing Lego, Biophar locates and co-ordinates multiple partners that all contribute a specific competence. During the third phase the company conducts some of the work in-house,

but most of the research is conducted by outside academic research groups across Europe. During the pre-clinical validation and clinical trials phases all research is conducted by external partners, located across Europe and, to a lesser extend, in the US.

C1.2.2 Sources of Knowledge

The main actors during the first two stages are academic research groups typically headed by an academic principal investigator who directs a varying number of post-doctoral and post-graduate scholars. These groups often collaborate on an international level. One of the most important sources of knowledge for the PI is academic journals. “Everyday I check *PubMed* [an online facility to search citations from life science journals], all the time, all the time.” The journals serve to keep the PI informed about what the competition is doing and it is a source for new ideas, new directions in his own research projects. In addition journals are consulted to solve specific problems, for example in relation to a specific technique. A second source of knowledge is discussions with other scientists, generally during conferences. Other important sources of knowledge for the PI are the collaborators and colleagues in the same institution. These represent an important resource for solving specific problems.

During the next phases - further R&D into antibody-based drugs for specific indications and pre-clinical validation – Biophar takes control of the innovation process. One of the main sources of knowledge for the company is the Scientific Advisory Board (SAB) that is made up of the four founders and external people from academia and industry. They provide important advice for project selection. The members of the SAB bring their opinion which is based on their knowledge in the field of immunology. Much of this knowledge is codified knowledge but this does not mean that it is accessible to all. “For me to be useful to Biophar I have got to be on top of the field and one way is to do my own research because I keep an eye on the literature and I am developing projects and all the rest of it … to allow this opinion to be valid.” (Interview SAB member). The members also bring their “know who”. They are well informed about relevant external advisors and partners. During the initial review, other important sources of knowledge to inform the selection include academic and industry literature (mostly on-line), and external clinicians that are approached to give their view.

After project selection an important source of technology is embodied in the intellectual property acquired from external actors. The knowledge involved tends to be fully codified. To the extent that the in vitro and in vivo studies are outsourced, the external partners are a core source of knowledge. For one specific indication the *in vitro* and *in vivo* studies are conducted in-house. For the group leaders the main source of knowledge is literature. One of the key functions of the group leaders is to know the literature in their specific field inside out, as soon as it is published and to assess whether it has an impact on the project. Next would be members of the SAB. The group leaders regularly approach the members to ask advice on specific issues. During the later stages of the product validation the core sources of knowledge are the external partners (e.g. toxicologists) and the literature, although the focus shifts from academic to industry literature.

Users, as in patients or patient groups, played no role during any of the stages. However, if we consider the clinicians as the users than these obviously constituted a very important source of knowledge from the third stage onwards.

C1.2.3 Finding Partners

During the third stage – further R&D into antibody-based drugs for specific indications – Biophar takes control of the innovation process. After selecting the particular TLR as a target it acquired the necessary IP. The university groups that hold the IP were identified by a combination of scanning academic and industry literature.

The external clinicians and research groups that conducted some of the animal studies were identified in different ways. The SAB members play an important role by suggesting potential partners on the basis of their knowledge of the literature and word of mouth. Biophar also used the internet to trace potential partners. In fact, one of the partners for animal models was found via a simply Google search, entering keywords and identifying the organisations that came up most frequently.

One collaboration was formed on the basis of an EU 6th Framework Programme. One of the founders was invited by an academic colleague to partake in a project researching a particular disease indication for the TLR20. Biophar agreed and subsequently found out that a partner in the Netherlands also had an expertise in other disease indications and had the models to test the antibody. A separate collaboration was formed to look at these different disease models.

During the subsequent stages of the innovation the choice of partner is driven less by the specificity of the disease, and more by considerations such as quality, ability to comply with regulatory authorities and cost. A single development manager at Biophar identifies and organises the contact with relevant external actors, including humanisation partners, manufacturing partners, regulatory authorities, hospitals, clinicians, contract research organisations etc. A number of potential actors are identified, typically through a search of industrial literature and on-line resources. In some cases such a search is followed by initial meetings during global conventions. A number of companies are asked to tender.

C1.2.4 Mode of Knowledge Exchange, Proximity and Level of Intentionality

The main actors during the first two stages are academic research groups typically headed by an academic principal investigator who directs a varying number of post-doctoral and post-graduate scholars. These groups often collaborate with other actors located in other countries. The level of face-to-face contacts varies from project to project. The interviewed PI would typically meet his collaborators twice a year but in some projects he had never met the collaborators. In many cases the meetings are combined with international conferences. The members of the research group typically have very regular phone and email contact with the collaborators, but compared to the PI they are less frequently involved in face-to-face contact. On the other hand, it does happen that, for specific purposes such as mastering a technique, lab members are stationed at the laboratories of collaborators for a number of month.

Partner choice appears to be relatively insensitive to distance decay. Partners are selected nearly solely on the basis of the specific knowledge they can contribute to the collaboration. Most knowledge flow can be satisfactorily organised via telephone and email. One of the PI's interviewed fro this case study expressed it as follows "I think on balance the collaborative aspect is nothing to do with where they are, its what they've got. So if they have that technique, if they have that approach. I suppose if its local its easier to get to maybe, easier for people to travel between labs and so on, just geographically. But it is more based on that need. So if someone in Timbuktu has that technique we will go to them anyway. None of the collaborations are contrived. They are all based on need"

The PI does appreciate the value of face-to-face communication. "My own personal view is that it is essential to have face-to-face meetings with collaborators because then you can spend time […] you can perhaps come up with ideas that wouldn't happen normally on the phone or by email (interview PI Stage 2). Face-to-face communication is particularly helpful for the initial idea generation and problem solving. It does however not influence partner choice. Apart from the fact that Ireland has few suitable partners, the amount of face-to-face contact required is limited and can efficiently be satisfied via sporadic long distance travel. It can often be combined with conference visits. The requirement for face-to-face contact of the actual lab staff is even more limited. Knowledge flow can be effectively organised by phone and email. The rare need for shoulder to shoulder work is satisfied by medium-term temporary geographical proximity.

During the next stage - further R&D into antibody-based drugs for specific indications – Biophar took control of the project. The acquisition of the relevant IP was did not involve actual collaboration between the actors. Most communication involved commercial negotiations. There was virtually no interaction on a scientific level. Some of the contract negotiations and paper work did require face-to-face meetings.

Within Biophar the three groups involved in the in vitro and in vivo studies work independently of each other on a daily basis. The scientist have daily contact with their group leaders who report the research findings back during weekly or bi-weekly face-to-face project team meetings, headed by a project leader. Apart from this, scientists have very frequent communication with other staff members, either within their group or across groups. Some of this is done face-to-face but an estimated 70 per cent of the communication is email-based. Face-to-face contact is used to deal with "issues", for example problems with a protocol for a specific test or experiment.

The external groups conducting in vivo and in vitro work worked relatively independently. There was limited day-to-day communication between these groups and Biophar. The project leader has email or telephone contact with the lead scientist in the partner group every four to five weeks mainly to discuss progress. Biophar typically has two face-to-face meetings with partners abroad. Items that are preferably discussed face-to-face include primarily contractual issues and grant opportunities. "Commerce, it is always better to have those discussions face to face". In addition the design of an experiment, the protocols and the data are in some cases discussed face-to-face although for many models the partners use phone and email. In relation to the external partner located in Ireland, all communication took place via email and phone.

Partner choice appears relatively insensitive to distance decay although all *in vivo* partners are located in Europe. This is possibly due to the fact that potential partners are distributed more ubiquitously than the academic groups involved in the earlier stages. Some science-related discussions are conducted face to face but for many models this is not necessary and telephone communication suffices. This is related to the type of knowledge that is communicated: "it is basically because when it comes to a protocol … in many respects it is sort of mathematical. In a way it is designed so that a conversation can be had over the phone". The need for face-to-face contact could easily be satisfied through occasional trips involving one or two members of staff. The choice for the Irish partner does not appear to be strongly driven by the idea that this may facilitate face-to-face communication. Although one interviewee made the point that a location in Ireland facilitates face-to-face contact, all communication with the Irish partner occurred by phone or by email.

During the pre-clinical-validation phase most of the actual research is conducted by external actors located outside Ireland, typically on a fee-for service basis. The co-ordination of the activities is virtually all done by two Biophar staff member, the VP of Pharmaceutical Development and, to a lesser extent, the Project Leader. The VP has frequent (weekly) communication with the external actors, although it depends on the stage the work is at. Most communication takes place by email and phone. Typically the VP would have two face-to-face meetings per year with individual external partners. The partner selection process often involves a site visit which obviously requires face-to-face contact. Business and contractual issues tend tot be dealt with face-to-face as well. The initial communication of test design and protocols is also conducted face-to-face. Here too partner choice appears relatively insensitive to distance decay although most partners are located in Europe. The need for face-to-face contact can be satisfied through occasional trips involving one or two members of staff.

Finally, the clinical trails stage will involve limited face-to-face contact with the CROs. After the initial meetings to discuss the detail of the study the CROs work independently and the results can be reported through email. Similarly the discussion of the results with external consultants does not necessarily result face-to-face contact. The selection of the CROs is driven by the location of the trials rather than proximity.

Although most knowledge flow is intentional, there is evidence of unintentional knowledge flow during all stages of the innovation trajectory and in some cases it can play a significant role. During the first two stages, an important source of knowledge for the principal investigators are other scientists. Conferences are an important site for exchange. Some of this exchange is intentional but the unintentional exchange is probably as important. "You go and hear people speak and very often the breakthroughs happen informally over a pint. You might be talking to another investigator and they will say something and you will say 'will you say that again'? And you will suddenly link two together and then have an idea … a lot of it can be very informal talk." Similarly, during the next stage, the intentional knowledge exchange with other academic research groups can provide important unintentional knowledge exchange. "Some people can back with certain knowledge; oh this is the way they do it. Maybe we should challenge the way we do it".

At Biophar, the use of digital environments for external knowledge exchange is limited to the email and the WWW. The WWW provides a number of resources to search the relevant literature (e.g. *PubMed*) and potential suppliers and other partners. The company does not use proprietary systems to organise the communication with external partners. Internally, the company uses a server-based system to file documents centrally and different groups of staff have access to specific folders. Electronic communication is conducted through email

C1.2.5 Importance of the Region / Ireland

From the perspective of Biophar the main reason for its location in Dublin was historic. The company was founded as a Trinity College spin-out. Initially the company was located at one of the founders' labs. After a number of years, under pressure from space constraints, the company needed to move. It wanted to stay in Dublin because all staff was living in Dublin and to retain easy access to the founders. The company moved to an incubator centre located at a university hospital in another part of Dublin. The hospital happened to have suitable space affiliated with the University. Apart from providing suitable space the hospital location provided little specific benefits to Biophar.

Apart from the founders, virtually all significant partners and other sources of knowledge in the innovation projects are located outside the Dublin Region, and indeed the Country. A number of actors that support the business side of the company - specialised accountants, IP attorneys and business advisors – are located in Dublin.

The relevant skills base in the region is relatively weakly developed. The company finds it difficult to find suitably qualified staff in the region. At the time the company was founded, some of the staff was migrated from the founders' labs to the company. However, the company regularly has to recruit suitable staff outside Ireland. "I think if our staff were to leave and we were to try and replace them with the same expertise, I think it would be difficult to get that in Ireland. I would think you would have to go outside of Ireland. Because biotechnology is only really starting off in Ireland"

The regional biotech cluster and sectoral system of innovation is still in its infancy and Biophar derives little direct benefit from it. The industrial promotion agencies have developed specific web-sites and networking tools but Biophar makes no use of these. "There is companies in Sligo and Cork (3 hours from Dublin) I have never heard of and there's all the NOVA companies at University College Dublin. It is very hard to find out what exactly is there". The founders have of course strongly benefited from the government policy in the area of science, technology and innovation, notably the growing funding of third level education and research, notably in biotech related sciences.

C1.3 TYPE OF KNOWLEDGE CREATION

The first stage - research into the TLRs and their functions - is very much the terrain of academic research departments The analytical mode of knowledge creation dominates. Knowledge creation during this stage of the innovation trajectory is concerned with unravelling the mechanisms of the immune system although even at this early stage researchers may have an idea as to its relevance for medical treatment.

The principal investigator (PI) involved in one of the many research projects related to TLR20 expressed it as follows: “We are in medical research, so we are trying to find mechanistic explanations for disease all the time. […] Obviously we work on a really basic level so whatever we discover could apply to many inflammatory or immune diseases. We don’t set off saying we are looking for a cure for arthritis. It is not like that. Its more a case of this pathway has been implicated in arthritis and can I learn more about it.”

Research projects typically start with a hypothesis about the functioning of the immune system, inspired by earlier work of the PI, journal articles and conference presentations. These hypotheses are subsequently tested in theoretically inspired research experiments. Based on the experiments the ideas are re-examined. The research experiments themselves tend to be highly formalised based on codified knowledge from journal articles. This is not to say that conducting the experiments does not require a level of tacit or experiential knowledge. “There is a very high level of technical skill when doing experiments. Techniques should be working but they are not. So you tweak this bit, you tweak that bit. You see if it will work now and eventually you get there”. “Lets say you got a question you are trying to answer and you realise there is a technique from some paper and try to set it up. If it does not work you will go to the person who published the technique and say look can you give me a better account of this”

During the next phase, research into how this knowledge can be used to halt inflammatory diseases, the analytical knowledge base again dominates although it includes a substantial synthetic element. The research process has many of the characteristics of the earlier stage. It is very much the terrain of academic research departments. The knowledge outputs are strongly codified, written up in patents. However, the development (engineering) of the actual antibody can involve a strong synthetic element. The aim is to develop a new complex technical system. The outcome of knowledge creation is concrete (the antibody) although it is not yet clear what precise indication it will cure.

During the next stage - further R&D into antibody-based drugs for specific indications – Biophar co-ordinates a number of research groups conducting in vitro and in vivo studies to establish whether the selected antibody has an effect on specific indications. The actual (engineering) work on the drug (the antibody) is finished. The focus now shift towards gaining knowledge regarding the effect of the drug.

In a way, from the perspective of the co-ordinating firm, this stage has an element of trial and error. The first two models (testing the effect of the antibody in relation to the first two specific indications) were unsuccessful after which the company pursued with two other indications. However, the selection of the specific diseases for further investigation was theoretically informed, based on codified knowledge interpreted by the members of the advisory board. The company combined various pieces of codified information and on the basis of this postulated that the target and antibody might be applicable in a specific set of diseases. “It is a matter of taking a quantum leap and saying no one has ever looked at this particular receptor in that particular disease”.

The actual experiments are highly formalised, based on existing protocols. The literature holds many protocols for different animal models for all disease indications.

The required knowledge to conduct the experiments is highly codified. “When it comes to a protocol … in many respects it is sort of mathematical.” How the study is set up, how the study is conducted, what the end points are, what we are looking for will all have been discussed and agreed at the team meeting prior to the study being started. At this stage too the techniques do require a certain level of tacit and experiential knowledge. “There are little tricks you would do that someone that would walk straight into it would not know”.

The following stage, clinical validation, involves a variety of activities, including toxicology (which is also based on animal studies), the humanisation of the antibody, and the manufacturing of the antibody. The interviews contained little information on these activities although it is clear that the toxicology studies have many of the characteristics of the earlier stage, again involving formalised animal studies. In addition we know that the knowledge outcome of all activities is highly codified.

The final phase will again be dominated by the analytical knowledge base. The activities do not change the actual drug. It is about gaining further understanding/validation regarding its efficacy. “A lot of theory and work has to go into selecting your patient population or sub-populations of disease patients to ensure you optimise your best chance for success”. The actual trials are highly regulated and standardised and the knowledge outcome is of a purely codified nature.

Table C1.1 summarizes the information regarding dominant knowledge bases and links this to the location of actors, the sources of knowledge and the salience of face-to-face contact between institutions

Table C1.1: Modes of knowledge creation, location of actors and intensity of face-to-face contact – biopharmaceutical drug project

	Dominant mode of knowledge creation	Location Actors	*Sources of knowledge (in order of importance)*	*Inter institutional face-to-face contact (frequency and number of people involved)*
1) Research to understand the immune system. The identification of TLRs and their function.	Analytical	Academic departments worldwide	e-Journals members of the scientific community in general collaborator scientists colleagues in the same institution	Global: Typically twice a year (PI only) can be combined with conferences Local: n.a.
2) Research into how this knowledge can be used to halt inflammatory diseases. Leading to the idea of using compounds that block TLR20	Analytical/ Synthetic	Trondheim University	e-Journals members of the scientific community in general collaborator scientists colleagues in the same institution	Global: Typically twice a year (PI only) can be combined with conferences
3) Further R&D into antibody-based drugs for specific indications	Analytical	Ireland, Europe, UK, Netherlands, France	Scientific advisory board (mostly local members) Academic and industry literature (on-line) External partners (clinicians) and service providers	Global: Typically twice a year (between project leader and lead scientist) Local: No f-t-f contact
4) Pre-clinical validation	Analytical	Ireland, UK, Europe or US	External service providers Industry literature (on-line)	Global: Typically twice a year (two members of staff
5) Clinical Trials	Analytical	Possibly UK, Germany, Australia	No data	(anticipated) Global: limited f-t-f contact

C1.4 THE ORGANISATION OF KNOWLEDGE COMMUNITIES AND CENTRAL OCCUPATIONAL GROUP

C1.4.1 Occupational Groups

On the face if it a stand alone firm, Biophar is deeply embedded within three broader sets of networks. These incorporate both different sectors and different occupational groups:

- Academic – research scientists working in the relevant scientific areas and located primarily within universities;
- Clinical – medical practitioner/ researchers whose interest is in the clinical applications of new treatments and/or the understanding of particular diseases;
- Specialised technical services - specialised contract organisations working in the areas of toxicology, manufacturing antibodies, clinical trials, and so on. These organisations exist largely in a 'merchant' relationship to Biophar rather than the complex relationships of 'co-produced' research that characterise ties to research and clinical scientists. Presumably the main occupational community here includes a heavy proportion of lab technicians, although it is telling that this never becomes visible or relevant.

Each involves a different model of organisation and occupational community.

C1.4.2 Heterarchical and Hierarchical Knowledge Flows

Within companies, there are of course ongoing discussions and disagreements about technical issues, future development trajectories of the drug, technical direction, commercial viability, and more. Biophar is no exception and interviewees outline a range of routine topics of discussion. These discussions are a matter of normal scientific practice – when you put scientists in a room together there will be disagreements.

The question becomes more complex when we consider three different dimensions: the significance of particular decisions and the uncertainties of research and development trajectories, the intertwining of technical judgments with disciplinary and occupational locations, and the mechanisms that companies such as Biophar use to resolve any disagreements that arise. Conventional hierarchical modes of decision making appear poorly suited to the task of coordinating, integrating and adjudicating such diverse knowledge flows.

Biophar is an 'information-rich' organisational environment with significant amounts of research literature, new research data and expert judgments at hand relevant to scientific decisions. However, interviewees speak of the importance of decisions that are based on judgments about future results or the expected outcomes of further research and testing. The available data are used to think through such decisions but they cannot determine the decision itself, as there are always elements of risk or uncertainty involved – as one interviewee puts it, 'it's like backing horses'. The most significant discussions, therefore, arise regarding topics as to whether to proceed with the development of a particular drug (Biophar dropped two other drugs and proceeded

with BIOP3), the testing of a drug in different clinical treatment models (the initial two clinical tests of BIOP3 failed to yield promising results but Biophar continued with other testing), and so on.

Despite the richness of the information available to Biophar, there is therefore always a strong element of uncertainty facing decision-makers within the firm.

Interviewees emphasise that these discussions are always on scientific grounds and rarely if ever are peoples' positions on the technical development motivated by a raw, narrow self-interest. However, they also note that the judgments made by individuals in different situations are shaped by their own location within the field. The most obvious differences are based on occupation and in many respects the Biophar network is organised to take advantage of occupational differences and diversity – the academics, doctors, technical experts and commercial people each bring different perspectives and insights to the process. This diversity, while greatest across the entire network of the Biophar BIOP3 process, is institutionalised within the company itself in the Scientific Advisory Board and Company Board, both of which contain a range of scientific and non-scientific members. There are many diverse flows of knowledge to be integrated within the firm.

However, interviewees also noted that it was difficult to separate individuals' judgments from their scientific locations. Clinical researchers, for example, were likely to lean towards the applications of the drug in their own areas as the most significant areas for future developments. While data and results were provided based on the norms of scientific practice, judgments were also shaped by discipline and occupation. This diversity of views is essential to Biophar, given the requirement to draw on different elements of specialised expertise and the potential benefits from their interaction. In this respect, Biophar is a 'heterarchical' organisation where multiple groups being different perspectives to bear within a relatively open structure. However, this diversity and heterarchy poses its own potential problems, as we have seen.

C1.4.3 Organisation of Knowledge Communities

As noted above, the relation with the specialised service organisation is largely of an arms length merchant character. However, ties to the academic and clinical communities are much more complex.

Biophar is highly dependent upon the existence of the academic disciplines of immunology and molecular biology. Biophar researchers network in to scientific communities via literature and conferences. They extract IP from this academic research field – this IP may be developed in house but in most cases will be external and bought in. The academic knowledge community is essential to the initiation and basis of the project but becomes less important as the drug is developed. Being part of the scientific community is essential to being able to identify and 'leverage' these bits of science (and/or IP). The goal of Biophar is then to turn the scientific finding/ IP into a working drug.

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It is interesting that Biophar founders were all owners of relevant IP and got together because of this but then ultimately have concentrated on developing a product that is based on IP developed elsewhere – the ultimate significance of their academic background therefore is their ability to understand the scientific landscape and see the significance of others' results, as well as carry out research and generate findings themselves.

In searching for the uses of the drug itself they draw on the clinical research community, tapping into their disease models – in a search for applications of the drug/ target technology. Network relationships had to be negotiated on this basis – one interviewee noted that in dealing with clinical partners there was a constant balancing act between generating a data package that could support Biophar's need for a test of the treatment effects of the drug while at the same time providing the data for academic publications required by the clinical researchers.

Biophar is carrying out the technological work of turning science into drug – along with these external partners. In each case the relationship with the external occupational group/ sector is different. Researchers must be networked into a diverse academic community, of which they are typically a part (at least at first). They must negotiate with clinical researchers whose professionally mediated access to, and control of, patient flows and disease data is an essential element of their negotiating power. This is of course mediated by the professional demands and responsibilities of doctors who retain the primary responsibility for patient welfare. The individual clinical researcher remains a vital gateway to that patient population. The relative importance of these communities ebbs and flows over the course of a project with the academic community being most important in the initial stages but waning as development becomes more crucial.

How does Biophar manage information flows, given both the density of those flows and the dilemmas noted above?

Some positions within the organisation are highly focused on the external environment and on integration with external knowledge communities. One development manager is dedicated to managing external relationships. Working relationships operate differently at different levels. PIs have occasional face to face meetings, based on long distance travel. Project teams have more regular contact, using phone and email. Sometimes – for detailed learning – staff travel to other locations for couple of months. In addition, group leaders' main task, according to one interviewees, is to stay on top of the literature – constantly scanning the available information for relevant knowledge.

The first main mechanism for resolving disagreements is routine discussion within teams. Scientific discourse and principles are crucially important as a structuring principle for these discussions. However, agreement is not always possible. Discipline may make a difference – one interviewee noted that it is difficult for people from different disciplines to have a dialogue when they disagree, as 'I am not a chemist' (implying that there may be fairly important differences in criteria across disciplines). Certain staff in leader positions play a critical role here in mediating disagreements – drawing on their 'wider scope and view' to try to resolve any such issues. It is worth noting the value placed on getting the 'buy in' of all concerned into the technological

trajectory, as reflected in the efforts put in to convincing dissenters of the decision to be made, rather than simply imposing it.

Where disagreements persist there are a variety of potential organisational mechanisms for resolving them. Some involve recourse to other parts of the organisational structure itself. Sometimes, teams will return to partners with technical questions and in search of more information, in the hope that additional will resolve the question. Other organisational responses involve a turn to more hierarchical methods – bringing questions to senior management, the founders, the Scientific Advisory Board, or even the Company Board. It is the Company Board that makes the most commercially critical decisions regarding drug continuation or discontinuation. Sometimes, the standing of the individual scientist will matter – one interviewee mentioned following the advice of a molecular biologist in one disagreement because of his long experience.

Other mechanisms for resolving disagreements relate more to the substance of the claims being made. Commercial considerations serve as a kind of limiting condition to technological developments – if the drug or technological process is not commercially viable or financially feasible, the discussion is over. However, there are also technical modes of resolving issues. This can often take the form of giving additional time (usually testing time) to people within the organisation to prove their argument by seeing if the testing process will generate more favourable results.

Summary
Ultimately, Biophar consists of a set of alliances around a series of technological and scientific trajectories – and these alliances are put together across occupations and networks, using scientific discourse, networks of agreements on processes and procedures, hierarchical mechanisms for resolving key issues, and problem solving at multiple different levels of the organisation. While Biophar is turning a scientific finding into a drug, it is also forging a network of interested parties into an alliance that structures the information flows around that process.

C1.5 ORGANISATION OF FIRMS AND MARKETS

C1.5.1 The size of firms

Over its life time the innovation process will have involved a wide range of actors. Apart from the small dedicated biotechnology firm the innovation involved academic research institutions, clinicians, and a large pharmaceutical firm. The large pharmaceutical firm does not enter the scene until the last stage of the innovation trajectory, phase three clinical trial. The individual academic research groups function relatively independently from the wider institutions that they are part of.

Biophar has adopted a “semi-virtual” business model whereby some of the research is conducted in-house but most of it is sourced externally. This reduces the required investment capital and makes the company highly flexible and agile in responding to technological developments and market demands. The open innovation model means that the company is highly dependent on external sources of knowledge and external partners.

C1.5.2 The age profile of firms

The dedicated pharmaceutical firm that co-ordinates the middle stages of the innovation process was only founded four year prior to the study. It was dealing mainly with long established academic and clinical institutions. At the final stage, clinical trials the company will most likely partner with a long established "big-pharma" firm.

C1.5.3 Type of user markets

The eventual end users are patients with a particular disease, often organised into representative associations and foundations. However the main "customers" of the drug are the medical professionals and healthcare organisations. When the innovation trajectory moves from gaining an understanding of the immune system to the development of a drug, these clinicians get involved and give their opinion regarding the feasibility of the project. Their ideas regarding the efficacy of the drug for specific indications, existence of existing drugs and other drugs under development and the size of the market played an important role in steering the innovation project. The actual end-users, the patients and the patient associations play a very limited role, at least until after the selection of a particular disease and the start of the clinical trials. At that stage Biophar intends to approach the relevant foundations to assist in "pulling together relevant information"

C1.6 INSTITUTIONAL CONTEXT

C1.6.1 Associational Networks

Biophar is relatively weakly embedded in networks of formal and semi-formal associations. As a spin-out from a local university, it retains links with this university. The university has a share in the company and the company is located in one of the university's incubator centres. However, the university's involvement in the management and governance of the company is limited. The most important links with academic institutions, both local and abroad, operate through staff networks.

The company has links with the national industrial promotion agency, Enterprise Ireland. This agency was actually instrumental in the naissance of the company by introducing the foreign entrepreneur to the local academics and by providing seed-money. In addition EI continuous to facilitate and fund networking activities where Biophar is introduced to potential business partners.

Biophar is not embedded in any national or international trade or industry organisations. EI has organised an online networking facility for the biotech industry (Biotechnology Ireland) but Biophar makes little or no use of it. In fact it is not even registered as a member.

C1.6.2 Forms of regulation

Bringing the innovation from the inception of the idea to the market takes a very long time and involves great costs and investments. In this particular case the initial discovery work started in the 1990s and, if successful the drug will not be marketed before 2013. This high level of investment in time and costs is to a large extent driven by the intense level of regulation. It is however not until the last stage of the

innovation process, the clinical trials, that regulation starts to significantly influencing the innovation process and the knowledge flow. Until this point the actors are regulated by the Environmental protection agency and the Health service Executive in terms of work environment – dealing with genetically modified materials.

The clinical trials are intensely regulated by national and International regulatory authorities. The trials and communication of the results are highly formalised. The involvement of thousands of human subjects and clinicians makes phase three trials very time-consuming and costly. In practice this makes it impossible for a small dedicated biotechnology firm like Biophar to go it alone. The company will necessarily have to involve a “big-pharma” firm. This may well take the form of a trade sale of the company or an initial public offering. The larger pharma company will be able to finance the costly trials. The actual trials will be organised by independent Clinical Research Organisations

C1.6.3 Finance

Bringing the innovation from the inception of the idea to the market takes many years and requires great investments. In this particular case the initial discovery work started in the 1990s and, if successful the drug will not be marketed before 2013. The greatest investments are required during the phase three clinical trials. Biophar intends to partner with one of the global big pharma companies to finance this stage of the innovation trajectory. This does no mean that the capital requirements before this stage have been insignificant. The size of the investments, the long period of financing required and the risks involved made venture capital an obvious option and in the first years the company raised over 6m in venture capital from a strong international investor syndicate made up of three companies. These firms don’t appear to directly influence the innovation trajectory of drug BIOP3

8 CASE STUDY 2

DEVELOPMENT OF A DNA-BASED MEAT TRACING SYSTEM – (FOODGEN)

C2.1 OVERVIEW

This case concerns the development of a DNA-based meat tracing system and service for the agri-food industry by FoodGen, a Dublin-based start-up biotechnology firm. Consumers have become increasingly concerned with food safety and the environmental standards of food production. The tracing system provides food retailers, processors and producers with the capability to identify and trace the source of meat products through the entire supply chain. The system compares DNA of samples of meat products at the end of the chain with the DNA-structure of samples of live animals at the beginning of the chain. This enables user of the system to contribute to quality and safety of the food supply and to enhance brand values. The main components of the technology include a DNA profiling platform, a sampling device and a data management tool. This, matched with a scientific understanding of marker systems in cattle provides a meat tracing service

The cradle of the innovation stood at the department of genetics in Trinity College Dublin. In 1990, a professor of genetics attracted research funding to apply DNA-level genetic profiling to improve cattle in tropical countries. Between 1992 and 1996, the research group involved two professors of genetics and three PhD students. The group was one of the first academic groups in the world gaining a DNA level understanding of cattle populations. The group used a recently developed genetic profiling technology based on micro satellite markers. The outbreak of BSE (mad cow disease) in the UK, and the associated fraud in the origin of cattle, instigated discussions among the team members about whether the newly developed genetic profiling technology based on microsatellite markers could be applied to develop a system and service to trace the origin of meat.

These discussion resulted in a meeting with Enterprise Ireland, the national support agency promoting indigenous enterprise development, who provided a feasibility grant. This basically financed a proof of concept study conducted by one of the Ph.D students in 1997. The study showed that it is possible to DNA profile cattle and use this to trace meat products. In the same year FoodGen was founded by the two professors and two PhD students as an on-campus company, located in the genetics department. The company filed an application for a patent on the idea of applying components of the microsatellite profiling technology for the purpose of meat traceability.

Still in 1997, the project attracted the interest of a large local supermarket chain, an Irish international meat packaging company and the national food authority, and the company attracted a large industrial development grant from the Department of Agriculture to further refine the idea into a commercial application. For this a number of challenges needed to be addressed simultaneously. First, until now the

microsatellite-based technology had been applied in a research setting, analysing small volumes of samples. For the service to be of use in the meat industry it had to be able to deal with large volumes of samples at low costs. Secondly, the company needed to develop an efficient devise to take samples from life animals in the meat processing plants. For this the company worked with a UK-based plastic injection moulding company. Thirdly, the company needed a customised data-management tool to deal with the sample and supply chain data. This was done in-house. Finally, the company needed to further refine its knowledge regarding the genetics of the European cattle population and to optimise its marker system accordingly. This basically meant identifying the markers that are most informative in differentiating between individual European animals and getting the chemistry work optimally. The actual science behind the microsatellite system and the technology for analysing the samples was however largely developed. The main challenge lay in adapting the scientific knowledge/technology for a commercial (large volume) application that could benefit industry at reasonable cost.

The company hired additional staff to support this research, all of which was still conducted in one of the laboratories of the Department of Genetics and managed in a research framework. The application was ready in 1998 and first commercialised in 1999. Several venture capital firms now invested in the company and the company relocated to a nearby incubator centre managed by Enterprise Ireland.

Although the commercialisation was relatively successful, after a number of years it became apparent that the technology did not provide the company with a sustainable competitive edge. The patent was successfully challenged by a foreign company and FoodGen had to abandon it. More importantly, the microsatellite-based system remained relatively limited in its capacity to deal with large volumes at low cost. For the company to grow, and access large scale markets such as the US, it needed to further develop its technology. In 2004 the company started to look for alternative technologies that could replace the microsatellite based system. Further innovation took place in all areas of technology. FoodGen started partnering with Bio-UK, a UK-based dedicated human biotechnology firm that had developed a system based on SMP technology, an alternative marker system amenable to larger volumes of samples. In 1998 FoodGen in-licence the technology platform and obtained exclusivity for the animal biotech sector. Although the system was fully developed, it required adaptation of FoodGen's technologies and processes before it could function in meat tracing. The new platform and the higher volumes required a re-engineering of the sampling devise and a new DNA extraction process, amenable to automation and high throughput, for which the company worked with outside partners. The larger volumes required a new data-management system for which the company hired new specialised staff. Finally, tracing meat in the USA, required additional research in the genetics of the US cattle populations to develop a new reference population and optimisation of the marker system.

Initially, the company outsourced the analysis of the samples using the new system to the UK partner. However, by 2008 the company had established its own system in a new laboratory in Kansas, the centre of the US cattle industry. This laboratory now analyses all meat tracing samples of the company world-wide.

We distinguish three different stages in the innovation trajectory.

1 Research into DNA-level genetic profiling of cattle in tropical countries.
2 Development of Tracing System Mark 1
3 Development of Tracing System Mark 2

C2.2 PATTERNS OF KNOWLEDGE FLOW AND INNOVATION

C2.2.1 Type of Actors and their Location

In 1989, research into DNA-level genetic profiling of cattle was very much in its infancy. Only a handful of academic groups in the world were undertaking this type of research based on microsatellite markers. By the mid-1990s the number of academic research groups involved in related research would have increased to about 20, all contributing elements to the overall understanding. The specific project of the Genetics Department at TCD was run largely as a stand-alone project without external collaborators. The project team involved two professors and, over the life of the project, three PhD candidates

During the second stage, the development of TS Mark 1, the proof of concept study was virtually completely conducted in-house, by a single Ph.D candidate/founder under supervision and with support of the other company founders. The research team contacted a small meat processing company in Northern Ireland. This company was interested in the idea and facilitated the proof of concept study by supplying meat samples. Following a successful proof-of-concept study new partnerships were established with a large international Irish food processor and a large Irish supermarket chain. Again, these partners had little involvement in the actual innovation other then facilitating the research by providing samples and a supply chain to test and further refine the system. The partners received first option to use the system if the results were to be successful. FoodGen was now in a position to hire additional staff. Much of the product development and refinement was now conducted by two new research associates under supervision of the initial Ph.D candidate/founder. Most of the required technology (instrumentation) was already in use at the laboratory. However the company needed to develop its own, dedicated, eartag sampling devise. The design and drawings for this devise were done by FoodGen while UK-based plastic moulding company manufactured it. The basic data management tool was developed by a brother of a member of staff hired on a summer contract.

The final stage, development of TS Mark 2, involved a redevelopment of virtually all elements of the integrated system. The new SMP based technology platform was inlicensed from a UK-based dedicated human biotechnology firm. Although the basic technology was fully developed, its application as a meat tracing system required a significant adaptation of FoodGen's related technologies and processes. This involved a certain element of collaboration between the two partners. The new platform also required a re-engineering of the sampling devise. For this FoodGen employed an Irish outsource design house. Although the actual drawing and prototype engineering was done by the design house, FoodGen staff was involved in the design process. Manufacturing of the tag was outsourced to a company in China. The new platform also required a new DNA extraction process. The required chemistry kits were supplied by a German company and adapted in-house. The company initially tried to

outsource the development of a more advanced data-management system but, driven by cost considerations, the company recruited specialised staff and developed it in house.

The required refinement and optimisation of the marker system was done internally by one of the researchers, now technology manager. This person, together with one of the original founders, was also responsible for most of the co-ordination of internal and external development activities. Finally, stage three saw the establishment of a Business Advisory Board. The board was installed to advise the company on the commercial direction and strategy of the company and includes high profile business actors and experts in various commercial sectors.

C2.2.2 Sources of Knowledge

The main actors during the first stage, research into DNA-level genetic profiling of cattle in tropical countries, are a relatively small number of academic research groups increasing general knowledge about microsatellite market systems. The TCD group did not collaborate with other academic groups. The main sources of knowledge for the PhD candidates conducting the research were academic journals, their academic supervisors (PIs), external academic colleagues and equipment suppliers. Academic journals were probably the most important source. The PIs had an extensive personal academic network that included academic groups involved in similar work. All members of the team exchanged knowledge with these university groups in all parts of the world, including the USA, the UK and the Netherlands. “People in the academic world share the knowledge fairly freely generally because there is not a commercial interest” (interview PI). The researchers could also “bounce ideas” on other colleagues in the same university working in related fields, but the interaction was mainly with people outside who were working on similar material

During the second stage, the development of TS Mark 1, the most important sources of knowledge were the company founders themselves. The initial idea was based on the team’s knowledge about microsatellite marker systems and the genetic structure of cattle population. In addition, having farmed and lectured meat science, the PI had a good understanding and was closely allied to the meat industry. The last element provided the company with important know who and market-type knowledge. Moving forward in this stage and later stages, some of the company founders retained their academic positions. Their academic work and networks remained a valuable source of knowledge. “I asked [the founding member that retained its academic position] to look into something … and he would do some research then in his own lab. …Well, he is working in that sort of area so he is a good gateway for us into the international literature on this.” (interview, company founder)

For the further refinement of the knowledge regarding the genetics of the European cattle population and optimise its marker system the researcher involved depended largely on academic journals that held most of the required information. In addition the responsible scientist would benefit from communication with the founders and, to a small extent, her own network of friends in science. The development of the eartag was to a large extent done in-house. The actual drawings were done by the scientists and handed over to the plastic moulding company. However the design process depended strongly on knowledge from the users, the meat processing company and the retailer. These actors provided crucial knowledge about the operational procedures

in the meat factories and supply chain that FoodGen lacked. “We had never been in a meat factory. The idea was simple in practice until you get into a meat factory and consider how it might operate”. The initial data management tool was relatively basic and developed entirely by the summer intern.

The sources of knowledge during the third stage, development of TS Mark 2, are in many ways similar to those in the second phase. One of the differences related to the new core platform technology, in-licensed from Bio-UK. Although the basic technology was fully developed, its application as a meat tracing system required a significant adaptation of FoodGen’s related technologies and processes. For this FoodGen depended heavily on the knowledge and undisclosed technological specification of the licensee. Another difference relates to the ear tag sampling device. Rather than conducting most of the actual design in-house, for the second device FoodGen relied more heavily on the knowledge of the external design house. Finally, in spite of the existing level of knowledge of the food industry that was available internally, the company needed to expand its level of understanding of the market place. For this reason it installed a Business Advisory Board which functions as a crucial source of market-related knowledge, supporting the innovation process.

C2.2.3 Finding Partners

The first and second stage of the innovation project the project involved very few partners other than the members of the academic research group, that subsequently became the founders of FoodGen. The few local industrial partners that facilitated the development of tracing system Mark 1 were easily identified by the company founders. Potentially more challenging would have been securing the involvement of these partners. It is here that the PI’s alliance with the meat industry and high esteem in meat science proved crucial. Most of the other partners, during stages 1 and 2 of the innovation trajectory, both local and abroad, were identified via simple searches using industrial literature or the Internet. As to the new core technology platform in stage three, the partner had been identified more coincidentally, through the academic network of one of the founders. FoodGen had been searching for a new technology that could deal with greater volumes of samples at lower costs. The UK-partner involved had only recently developed an SMP based platform and was providing its services to an Irish university. One of the founders saw the system in use, realised the potential for FoodGen, and contacted the company directly.

C2.2.4 Mode of Knowledge Exchange, Proximity and Level of Intentionality

During the fist stage of the innovation trajectory, research into DNA-level genetic profiling of cattle in tropical countries, the specific project of the Department of Genetics was run as a stand-alone project, without external partners. Members of the research team did exchange knowledge with other academic groups all over the world involved in similar work, with their academic networks in general, and equipment suppliers. Much of this exchange happened face-to-face, during international conferences, workshops and lab visits.

During the next stage, the development of TS Mark 1, the main external partner was the UK based plastic moulding company that manufactured the ear tag. The intensity of collaboration and knowledge exchange was limited and involved very limited face-to-face contact. One of FoodGen’s researchers made the actual drawings and sent

them to the UK. The UK company developed a prototype which was approved after a single meeting.

The third phase, the development of TS Mark 2, involved more intensive collaboration with external partners. In relation to Bio-UK, the adoption the core technology platform required significant adaptation of FoodGen's related technologies and processes. FoodGen encountered significant challenges, optimising the technology, getting the chemistry right, getting an understanding of how to copy the production line of Bio-UK in their own food-diagnostics environment. Over a two year period one of FoodGen's researchers had about six face-to-face meetings in the UK. At some of these occasions the researcher worked shoulder to shoulder with scientific staff of the licensor for a couple of days to iron out the problems. In addition, the researcher had intensive communication via email.

The development of the second ear tag also involved more intensive collaboration and information exchange. During the design process the responsible researcher at FoodGen had intensive contact with the Irish design house. Communication by telephone or email occurred a couple of times a week. A substantial part of the communication was conducted face-to-face. The engineers of the design house were brought along to the meat processing plants for discussions with the technical and quality managers so as to get a good understanding of the requirements. This was followed by a sequence of design cycles starting with face-to face conceptual discussions, followed by prototype design by the external partner, face-to-face discussions, testing in the field and face-to-face evaluation.

The choice of the UK partner does not appear to have been sensitive to distance decay. The UK partner was selected primarily on the basis of the specific technology it could contribute to the innovation. In addition, the interviews suggest that the required level of face-to-face interaction is not a strong factor in the choice for this partner, at least on a European scale. "I see Germany and the UK as pretty local really … it is not a big issue." (Interview research scientist) "We saw the UK as very close by and sometimes one could argue they are located close to Stansted and one could get there easier there then you could commute into town in the morning." (Interview founder) The choice of the Irish design house seems to have been more sensitive to distance decay. "I suspect that [the close location of the design house] would have been a requirement for us because we certainly had a sense that this was a unique design project and would have needed very close co-operation between ourselves and themselves." (interview founder)

As regards the intentionality of the knowledge exchange, the most vital knowledge is exchanged intentionally. Unintentional knowledge exchange, often during academic conferences, plays the greatest role during the first stage of the innovation trajectory. During the later stages, unintentional knowledge exchange and 'buzz' appear to play a minor role. Although, it did play a role in the identification of the partner for the mark II platform technology. This partner and the technology was identified coincidentally by one of the founder scientists, when visiting the lab of one of his local academic colleagues.

At FoodGen, the use of digital environments for external knowledge exchange is limited to email, *Skype* and the Internet. The latter is used to access the academic

literature, for supplier search and for recruitment purposes. Some researchers have signed up to *PubCrawler*, a free Internet-based alerting service that scans daily updates on various Journal databases

C2.2.5 Importance of the Region / Ireland

FoodGen is located in Dublin, the domicile of its academic founders. The company was founded as a Trinity College spin-out. Initially the company was located at the lab of the founders. After a number of years the company moved into a nearby incubator centre.

As the location of the university that employed the founders and the cradle of the initial ideas, the local region has obviously played an important role in the in innovation trajectory. However, after the first stage the role of the region becomes less salient. Apart from the founders, virtually all external partners and other sources of knowledge were located outside the Ireland. Only one of the external partners in the innovation project was located in Ireland. None of the interviewees had the idea that the company enjoyed a direct advantage of being located near the other biotech companies in the Dublin area.

The local universities, as a source of skilled labour, are an important asset to the company. The company recruited much of its 35 staff from the local third-level skills pool and institutions. According to one of the interviewees it would have been more difficult to satisfy the staff requirements in a more rural location outside of Dublin. Having said that, the required levels of qualification are relatively limited. Although most of the staff holds a third-level qualification, only the founders hold a Ph.D. Only four staff members, included two company founders, have a direct role in product development. On an international scale, market considerations are probably a more important location factor.

> If we were setting up from the novo, if we were coming from mars up here on earth [we would set up elsewhere] because we are very much focused on the marketplace. We would set up in the country with the biggest markets. So we would probably gravitate towards the United States, potentially Brazil or other markets like that. So form that perspective Ireland wouldn't be a good choice (interview founder scientist)

The company derives little benefits from the regional or national biotech cluster and sectoral system of innovation. The industrial promotion agencies have developed industry-specific web-sites and networking tools but none of FoodGen staff make use of it. Probably the most important local institution is the Department of Agriculture that provided the company with the first large industrial grant. The links with the Department remain important in proving the company with a level credibility in the face of its customers. Yet similar relationships are nurtured with equivalent departments in other countries.

C2.3 TYPE OF KNOWLEDGE CREATION

Stage 1, research into DNA-level genetic profiling of cattle in tropical countries and DNA based investigations into cattle populations in general was virtually exclusively conducted by academic research groups. The analytical mode of knowledge creation clearly dominated. The aim of the research was to create new knowledge about

natural phenomena. It was about understanding the causal mechanisms that lead to genetic differences and similarities between cattle populations. Although the researchers and the funding organisation clearly understood how the knowledge could impact on the productivity of cattle, during this stage researchers were not working towards a concrete outcome or developing a new functional system. In fact one of the first and main publications resulting from the work was published in an anthropology journal because of its relevance to domestication theory

The research project was entirely laboratory based, involving the processing of samples to test hypotheses. The tests were formalised, based on codified knowledge obtained from academic journals. Research output was again highly codified, published in academic journals. Yet, the experiments did require a level of tacit and experiential knowledge, notably related to the technology and techniques.

> There were a whole series of technical challenges, there wasn't any single one. Initially extraction of DNA, purification of the DNA, prevention of contamination of your samples were all very important so there was a whole series of technical things that [the Ph.D candidate] had to learn and he had to learn by doing and learn by going to see people in other labs and so on, the usual sort of thing by reading the literature, by talking to the people who developed the equipment that you use so all of that was a sequence of refinements of the technology. (Interview principal investigator)

The second stage of the innovation trajectory, the development of Tracing System Mark 1, involves a set of separate innovations characterised by different knowledge bases but the synthetic mode clearly dominates. The outcome of all the knowledge creation activities is concrete. Activties have to lead to the development of a new meat tracing system, a new complex technical system. The development of the ear tag, although not central to the activities of FoodGen, was a vital element of the overall system. It was a pure engineering job. Initial result of the knowledge creation was a blueprint (simple drawing) that described the functioning of the system on paper. This was translated in a prototype which was tested in practice. The knowledge creation could not be conducted and completed in a laboratory. The design effort required a good understanding of, and contact with, the use environment.

Another important element of the innovation at this stage was the refinement of the panel of genetic markers used in the meat tracing system. This had some characteristics of analytical knowledge creation in that it expanded, to some extent, the knowledge regarding the functioning of the mechanisms that leads to differences between cattle populations. The activities and tests are theoretically informed and highly formalised, based on codified knowledge from academic journals and the knowledge output as well is highly codified - at this stage no longer published but in the form of patents, or kept in-house. From another perspective the refinement activities were more in line with the synthetic mode of knowledge creation. Again, the main purpose of the activities was to develop a new system, not increasing our understanding of the mechanisms per se. In fact, the activities added relatively little to the existing level of understanding regarding the genetic profiles of cattle populations. The real understanding was created through research activities in the Department of Genetics and other academic groups, as described in stage 1. "I would see [the activities stage 2] as development because somebody else went through the trouble to find the marker and say that this microsatellite exists in this region and this is the sequence." (Interview technology manager) During stage 2, FoodGen applied existing

codified knowledge regarding marker systems which is available in journals and the Internet, and verified its use for its industrial application and optimised it. “We take things that are already ninety percent there and we put them into our system”.

Although most information if codified and publicly available and the required technology was on the market, exploitation required a high level of absorptive capacity. This is where the scientific background of the founders was crucial. During stage 1, the research team had developed a strong knowledge of marker systems and how they behaved across different breeds. This scientific understanding enabled the researchers to select the right marker systems for their industrial application in different geographical locations.

The final stage, the development of Tracing System Mark 2, has many of the same knowledge base characteristics as phase two. The refinement of the panel of genetic markers was again best described as a combination of analytical and synthetic modes of knowledge creation while the synthetic knowledge base again dominates the development of the second sampling device (ear tag). The interviews paint a clear picture of a trial-and-error process. “[The engineers of the design house] would then go away, and come back with a whole platform of different designs. We would dismiss a whole bunch of them saying this is not going to work and then we would narrow that down to a few and then we would field test them.” (interview technology manager)

The adaptation of the SMP platform technology was also most in line with the synthetic mode of knowledge creation. The basic technology was largely developed by the UK-partner. “They were very much hands on. So they were very much like engineers, getting in, tweaking with robots and doing all sorts of technical innovations” (interview founder scientist). The application for the meat industry was a one-off product. Changing the technology into an application for the meat industry was also largely done by the UK partner but it did require an adaptation of FoodGen’s related technologies and processes. This did however not involve gaining a new understanding or formal processes. It mainly was a matter of tweaking and fine-tuning the chemistry involved, problem solving and testing in practice. A lot of the information required for the knowledge transfer was not codified.

> What was important [with the UK partner] as well was optimising, getting the chemistry right making sure it worked with their platform and then getting an understanding of how we needed to copy their kind of production line and set it up in Kansas. So spending time there just walking around taking photographs chatting to people about what you need to know. To make this work you need to have that access to water or compressed air. [The UK partner] had never before replicated their platform in another environment. So it wasn’t documented in anyway they didn’t give us any kind of lab SOPs or anything so we had to put all that together so definitely yeah face to face time there was valuable. (Interview technology manager)

Finally the development of the more sophisticated data management tool was characterised by a synthetic mode of knowledge creation. The aim is to develop a new one-off technical system. The actual activities involve designing, problem solving and testing in practice. “I worked very closely with [the programmer], specifying what I needed and then he’d code something and come back and we’d try it and then go … this won’t work because we need this and that probably went on for about six months.

(…) But now we are integrating that tool with the functionality of the sample management into a whole new application." (Interview technology manager)

After focussing on the relevance of the analytical/synthetic knowledge base and mode of knowledge creation it is important to point to the importance of a specific type of knowledge in the innovation trajectory – market or industry knowledge. "The Eureka moment was not some new technology, it was the application of this technology to large scale commercial meat production. (…) While that was simple, nobody had done it, nobody had proposed it, Nobody had considered it." (Interview, founder scientist) The innovation would not have been conducted by the specific academic group without the lead researcher's understanding of the structure, functioning and needs of the meat processing industry. Later, during stages 2 and 3 the main challenges were related to understanding the specific needs of the meat processing sector, how it operates and how the technology can add value for the industry. "Why we had we had to innovate a lot is because of the market place rather then the technology side. So we have had to invest a lot more energy to pull resources in there and better understand that and it is in that context we have [established] the Business Advisory Board." (Interview founder scientist)

Table C2.1: Modes of knowledge creation, location of actors and intensity of face-to-face contact – meat tracing project

	Dominant mode of knowledge creation	Location Actors	*Sources of knowledge (in order of importance)*	*Inter institutional face-to-face contact (frequency and number of people involved)*
1). Research into DNA-level genetic profiling of cattle in tropical countries.	Analytical	Academic department	e-Journals members of the scientific community in general	Global: couple of times a year (conferences) Local: n.a.
2) Development of Tracing System Mark 1	Synthetic (ear tag) Analytical/ Synthetic (refinement marker system	UK partner Ireland (Focal company)	Users (meat factories Ireland) e-Journals Company founders Members of the (local) scientific community in general	Global (UK): Once over the entire project (technology manager only) No f-t-f. with external actors (For analytical/synthetic)
3) Development of Tracing System Mark 2	Synthetic (ear tag, technology platform, data management system) Analytical/ Synthetic (refinement marker system	Ireland (focal company), Irish partner, UK partner and Ireland (Focal company)	Partners (Ireland and UK) Users (in relation to ear tag) e-Journals Company founders Members of the (local) scientific community in general	Global (UK): six occasions (including multi-day) over a 2-year period (founder and technology manager) Local: between five and ten meetings (techn. manager) No f-t-f. with external actors (For analytical/synthetic)

Note: market/industry knowledge is a crucial knowledge type during stages two and three. The Business Advisory Board is an important source.

C2.4 THE ORGANISATION OF KNOWLEDGE COMMUNITIES AND CENTRAL OCCUPATIONAL GROUP

FoodGen offers a fascinating case study of how knowledge matters, even in a relatively standardised setting where the core scientific had been done and was relatively widely available. Nonetheless, FoodGen's efforts to develop a technology around this science that could be applied across large volume testing reveals the continuing importance of scientific knowledge and knowledge communities, even in businesses that are less directly focused on scientific innovation itself.

C2.4.1 Occupational Groups

The interviewees attest that there have been few major disagreements within the firm's evolution. Each sees the same cause behind this. The founders of the firm have a shared vision of the company's identity and strengths. This is rooted in their disciplinary and scientific backgrounds – 'we all come from the same stable', as one interviewee puts it. The founders all come from the discipline of genetics and within this have a strong focus on veterinary/ animal science. In addition, they shared from early on a commitment to being close to the agricultural market.

In this context the main occupational group is the scientific discipline of genetics. But the firm also clearly identifies a particular relation to genetics and to biotechnology mreo generally, emphasising its distinctiveness. The scientific background of the core team in the firm enables them to interpret the data from their sampling and testing technologies and this in turn is linked with industry and market knowledge. Animal genetics therefore places the team in a very specific location at the intersection of agriculture and genetics and this has a defining impact on the firm.

There are few other occupational groups within the firm that have a discernible say in the development of the company. This is partly because the production orientation of operations managers and the commercial orientation of marketing departments have already been incorporated within the perspective of the core team. In addition, the small size of the firm means that there is not, for example, a separate marketing department.

C2.4.2 Heterarchical and Hierarchical Knowledge Flows

The firm is small and cohesive. There seems to be relatively little hierarchy within the founder group itself, although it is clear that it is this group that drives the company. At the same time, the external partners are less important in shaping the direction of innovation than in Biophar (case 1). This 'cohesion without hierarchy' in FoodGen is based on a strongly shared understanding of what the firm is doing among key staff.

The founder group is close-knit, with even those who have gone on to roles elsewhere or to non-executive roles within the company, staying in close contact. The tightness of the group seems likely to be in part due to the development of some of the founders' professional identities under the influence of the most senior founder, who was PhD supervisor to a number of the other key staff.

There are external knowledge flows but these are largely integrated through the core team. There is little mention of competing views of how the company might develop –

with the only conflicts emerging with external actors (such as Trinity College when the company was commercialising). There are no major occupational groups outside the core animal genetics group. While the mission of the firm is clearly defined and tightly held, it also incorporates the production, science and commercial perspectives.

If the firm grows to the point where it generates different divisions in these areas, more complex issues might arise about knowledge flows. Some signs of this exist in the developing US operations:

"We should have avoided those core scientific conflicts now with some of our team that was brought on in the US. There have been some {} that have been different perspectives… There would have been more of those types of conflicts… "

However, at present the organisational structure of a cohesive core team with a shared longstanding view of the company's strategy maintains a unitary view of the firm (that is neither particularly hierarchical nor heterarchical).

This is all the more interesting as the firm does engage with academic knowledge, particularly in the early stages of its development but also on an ongoing basis. We can see a broadening and narrowing of knowledge base/ networks at different times in company development. There are broader networks and dialogue with other researchers during periods of technological innovation, and then a narrowing and focus during application (although in these stages there is greater engagement with users and the industry, engaging market and user knowledge).

C2.4.3 Organisation of Knowledge Communities

The networks of FoodGen are much less dispersed than those of Biophar (case 1), although they do shift over time. The cosmopolitan knowledge in academia was an important starting point. The firm was integrated into international academia from an early stage through the senior founder's US connections (from PhD research) and EU funding ties. This continues in a variety of ways – including continuing ties with the Genetics department at Trinity, ongoing informal consultations with founders who have since left and regular internet searches relating to literature and industry developments.

There are also multiple forms of academic knowledge that need to be accommodated . For example, skills in laboratory work needed to be developed within the core team, despite the senior founder's lack of knowledge in this area: "you automate as far as you can but there was still the hand and eye reading of gel so there was a lot of human activity". Far from being simply a mechanical or routine skill, acquiring this knowledge was important to the company's ability to develop its products and the knowledge was gradually developed through networking with the broader community of academics and learning on the job.

Ties to agricultural and food industry users of the technology were important and extensive from an early stage. Overall, the company's networks start with academic knowledge and the world of academia. As they move into the application of the technology there is greater engagement with local industry and reliance on founders' knowledge and continuing academic connections, rather than the knowledge of the broader scientific community. Finally, the need to establish the process on a new

technological platform brought the company into contact with a variety of international technology providers. However, the scientific knowledge base of the company remained important in tweaking and adjusting the technology to the FoodGen system.

It is interesting how important the internet is as a source of initial information, scoping out who is doing what within a field. It also proves to be a resource in monitoring both academia and industry – not just knowledge bases but also social networks. Nonetheless there is some evidence that the company preferred to deal with local companies for complicated tasks, even though most of their connections are international and relatively independent of distance (although primarily within Europe).

C2.5 ORGANISATION OF FIRMS AND MARKETS

C2.5.1 The size of firms

The innovation trajectory involved a relatively small amount of actors, the initial academic group, the small company that they founded, a handful of small-sized firms that provided complementary knowledge and technology and a number of venture capital firms. The initial academic group functioned relatively independently from the large academic institutions that they were part of. However, there are ongoing informal connections to the department of origin.

The low level of regulation meant that the innovation trajectory required relatively little time. Although the academic group had been investigating the profile of cattle populations since the early 1990s, the development of the traceability system took only two years from idea to the market. However, the company's fate is also closely linked to patterns of regulation as, for example, EU-mandated traceability of meat offers huge potential markets to the company.

Although the development required substantial investment capital, secured from the EU, state agencies and venture capital firms, the investments are small compared to what is needed for the development of a bio-pharmaceutical product. This means that the company continues to function as a privately held limited company, while the core sources of knowledge remain internal to the firm.

C2.5.2 The age profile of firms

At the time of the research the focal biotechnology firm was only 10 years old. The main (UK) partner was a young small dedicated biotech firm as well. However, the initial research upon which the firm is based began with a grant in 1989. Given that the firm remains quite small, this illustrates the slow pace of development of many firms, even in an apparently fast moving field.

C2.5.3 Type of user markets

The user market of FoodGen is different is from most other biotechnology companies. The typical biotechnology company sells technology or science based products or services into another science based organisation. FoodGen sells science-base product solutions into a non-science based environment, the food processors and retailers.

These users have a very limited understanding of the science underpinning the innovation and contributed very little to the technological and scientific development process. They merely facilitated the innovation by discussing their operational procedures and providing samples.

The innovation of FoodGen provides an answer to the increasing demand of the final customer for food safety and environmental standards. However, the success of the innovation depends on the willingness of food processors and retailers to adopt the system. The meat industry has traditionally had a strong production focus It is only recently that we are experiencing a move to a greater consumer focus. FoodGen has little influence on this shift. However, increased concern with integrity of the food supply may mean that an increasing number of technology companies may operate in this kind of environment.

C2.6 INSTITUTIONAL CONTEXT

C2.6.1 Associational Networks

FoodGen is relatively weakly embedded in networks of formal and semi-formal associations. As a spin-out from a local university, it retains links with this university. The university has a share in the company. However, the university's involvement in the management and governance of the company is limited. The most important links with academic institutions, both local and abroad, operate through staff networks. There are informal links with the department of origin that play a minor, yet occasionally significant, role.

The company has links with the national industrial promotion agency, Enterprise Ireland. This agency funded the first proof-of-concept study and provides the company's incubator space but does not act as a source of knowledge. EI has organised an online networking facility for the biotech industry (*Biotechnology Ireland*) but FoodGen makes no use of it. FoodGen is not embedded in any national or international trade or industry organisations.

C2.6.2 Forms of regulation

Although the food industry is highly regulated, there is as yet no mandatory meat traceability in the food industry. Meat processors and other actors in the value chain do use the system on a voluntary basis. Any EU regulation in this direction would be a critical development to the company and will possibly affect the innovation trajectory and knowledge flows.

However, the development and marketing of the current meat traceability system was relatively unregulated. The Department of Agriculture in Ireland and the USA did audit FoodGen's services to make sure that the customer's claims are scientifically supported but, compared to the regulation involved in developing a bio pharmaceutical drug, this is very light-touch regulation.

The low level of regulation meant that the innovation trajectory required was finished in a relatively short little time. Although the academic group had been investigating the profile of cattle populations since the early 1990s, the development of the traceability system took only two years from idea to the market. Still, the development

of the system and the commercialisation at an international scale required a substantial amount of funding from venture capitalists. The company remains a privately held limited company.

C2.6.3 Finance

The low level of regulation meant that the innovation trajectory required relatively little time. Although the academic group had been investigating the profile of cattle populations since the early 1990s, the development of the traceability system took only two years from idea to the market. Still, the development of the system and the commercialisation at an international scale required a substantial amount of funding. The initial development costs, the wages of one or two junior scientists, could be financed with the grants of the development agency and the Department of Agriculture. But the further development and commercialisation of the innovation required more substantial funds. Given the risks involved these were secured from venture capital firms. There is no evidence that these directly influence the innovation trajectory. The company remains a privately held limited company.

9 CASE STUDY 3

DEVELOPMENT OF NEW DELIVERY TECHNOLOGY FOR BIOPHARMACEUTICAL DRUG – (TABPHARMA)

C3.1 OVERVIEW

This case study concerns the development of Tab1[5], an oral dosage form of an existing intravenously administered biopharmaceutical drug for metastatic bone cancer. The structural characteristics of the biopharmaceutical active ingredient mean that it is poorly absorbed across the intestinal barrier. Therefore currently, the blockbuster drug is administered by intravenous infusion. In Tab1, the active ingredient is combined with an enhancer system (excipients) that increases the permeability of the intestinal wall. This allows the medication to be administered orally, with greater comfort, less side effects and at lower costs. At the time of the research (2008) the project was managed by Tabpharma, a privately owned, Irish, dedicated biotechnology company located in Dublin. However, the basis for the innovation was laid in the early 1980s.

At that time multiple research groups, both in academia and pharmaceutical companies, were conducting studies into biological absorption mechanisms and drug delivery technology. Among the players was Firstpharm, a relatively young, Irish, medium-sized pharmaceutical company, focussing on controlled release drug delivery technology. In an effort to expand its technology base, in 1990 the company established a small laboratory on the grounds of Trinity College Dublin. The group started small with a biologist who was allowed to hire a small number of PhD students. His brief was very broad, to set up an in vitro lab and conduct R&D into transport models for oral delivery. After a half a year of desk-based research he decided to focus the research on the idea of using agents to open epithelial tight junctions in the intestinal wall. This decision was driven by his own research expertise and the interests of the company. For the next number of years the relatively small research group conducted research into the ability of different agents to open tight junctions

The company increased the resources into this research and the group gradually expanded. After a number of years the company was confident enough to select a small number of agents (enhancer systems) for more upstream research R&D activities. The absorption enhancer systems were now applied in the early stage development of oral doses of specific (existing) drugs. This up-stream research activity required the addition of other competences and functions in the form of a solid dose formulation group and an analytical group. By 2002, Firstpharm had secured a number of patents on related drug delivery technologies and was conducting pre-clinical research on the development of oral doses of a handful of existing drugs.

[5] Tab1, Tabpharm and Firstpharm are fictive names.

At this point, as part of a major restructuring, the company decided to divest some of its drug delivery business and all 50 staff of the R&D laboratory at Trinity College was made redundant. The existing patents and data related to the generation of drug delivery technologies developed by the laboratory in Trinity are acquired by a small indigenous venture capital group which founded Tabpharma, a new biotechnology company, to further develop the IP and bring the delivery platforms to the market.

Again in a laboratory in Trinity College, the new company started off from where the Firstpharm had left, although it did not involve itself in the relatively more fundamental upstream research activities. There was no longer a biology group. Resources were now firmly concentrated on the further development of oral dosage formulations for Tab1 and other drugs, starting with the continuation of drug development and the pre-clinical trial work. The company's in-house formulation group first developed an oral dosage. This group was also able to manufacture the drug in its CGMP accredited facility. The required active ingredient could simply be bought from a generics manufacturing company. In the pre-clinical studies, before a drug candidate can be tested on humans, it is subjected to further tests, including animal models. All this work is supported by the analytical group responsible for developing some of the tests as well as conducting the tests. The actual administration of the drug to the animals was contracted out to a US company and the samples were analysed by Tabpharma or analytical services companies. The pre-clinical work confirmed that the drug had potential and further IP was secured, both related to Tab1 and the platform delivery technology in general.

In 2006 the product is ready for clinical trial during which the product will be tested in increasingly large number of human subjects. Phase I was completed in 2006, Phase IIa and IIb in 2008. The trials were conducted at multiple sites, mostly in the USA and two in Latvia and Estonia. Most of the actual trials and initial data analysis is be conducted by clinical research organisations (CROs). The Chief scientific officer responsible for clinical development (located in the US) selects and organises the contact with relevant external actors, including contract research organisations, regulatory authorities, hospitals and clinicians.

At the time of reporting the company, again employing 25 people, is preparing for the final, Phase III, clinical trials. Since the active ingredient is already on the market, these trials are relatively undemanding and require relatively limited financial capital. At the time of the research the company is trying to find a potential licensee to take control of phase III clinical trials and market the product. The large "big pharma firms" are the most likely partners in this respect.

We distinguish three different stages in the innovation trajectory.

1. Research into the ability agents to open epithelial tight junctions in the intestinal wall
2. Development of oral doses for the specific drugs and pre-clinical testing
3. Clinical Trials

C3.2 PATTERNS OF KNOWLEDGE FLOW AND INNOVATION

C3.2.1 Type of Actors and their Location

In the early 1990s, Firstpharm's research group was one of many in the world, both in academia and pharmaceutical companies, conducting research into the ability of agents to open epithelial tight junctions in the intestinal wall. Academic departments worked independently or in collaboration with other academic groups worldwide while research groups in companies tended to work more independently. Firstpharm conducted this stage of the research in relation to the drug delivery technology supporting Tab1 independently. Firstpharm was involved in joint venture with an American biotech company that had an enhancer targeting the same mechanism but this did not develop. The biology research group in Firstpharm was initially relatively small, consisting of a biologist with a PhD and relevant research experience at Cambridge and Stanford and a small number of PhD candidates that were paid by Firstpharm to work on the project

The first steps of the next stage, the development of oral doses for Tab1 and pre-clinical testing, are again conducted by Firstpharm. The biology group has done its work and it has little involvement in the further development. Intra-firm the main actors are the formulation and analytical groups. Initially during this stage, virtually all the work was done in-house and very few external actors were involved. It involved no other universities. This was partly due to the specific business strategy in relation to Tab1. Some of Firstpharm's products were developed in partnership with external companies (all outside Ireland). These external actors owned an active ingredient and the two companies would partner in the development of a new oral dosage. In some cases this involved a joint-venture arrangement. In the case of Tab1, Firstpharm identified an existing drug that was near to patent expiry and started working on an oral formulation with the idea to sell or license it at a late stage of development. The required active ingredient could simply be bought from a range of fine chemicals or generic pharmaceutical companies, involving an arm's length transaction. In the case of Tab1, the active ingredient was bought from a company in India.

With the restructuring of Firstpharm the IP is acquired by a local venture capital company. This company founded Tabpharma to exploit the IP and brought together a management team of three people with complementary experience on the business side of the pharmaceutical industry. Two of these people, The CEO and the Chief Scientific Officer lived and would continue to operate out of a small office in the US. Again, much of the development work in relation to Tab1 was done in-house, mainly by about two scientists in the formulation group and two in the analytical group. The project team is lead by project leader. Although there is continuous communication between the members of the project team, there is limited shoulder-to-shoulder work. Results are reported in weekly project meetings. The overall activities were coordinated by the chief development officer.

Although much was done in-house, the now smaller company necessarily relied more on outside services. For example in the context of the in vivo pre-clinical studies, the actual administration of the drugs into the animals was conducted by a contractor in the US (but the analysis of the samples was done in-house or outsourced to other service providers). In addition the company contracted out a range of routine analytical services to various labs in the US, Canada, UK and Europe, including one

in Ireland. In the majority of cases the method tends to be developed in-house. However, in some cases a validated method already exists externally and this is an important reason to select a particular external service provider. Although the company is no longer involved in early stage research into the functioning of the human body, it is important for the company to have access to knowledge and new developments in methodologies and techniques that may influence formulations. For this the company uses the consultancy services of the scientist that initially worked on the drug delivery system, now employed as a professor at one of the local universities.

At the start of the clinical trials stage the important analytical plan for the trials is set by the company, based on advice from the strategic advisory board. After this most of the actual activities are co-ordinated by several CROs in the different locations (USA, Latvia and Estonia). Internally the Chief Scientific Officer (located in the US) selects and organises the contact with relevant external actors, including CROs, regulatory authorities, hospitals and clinicians. The required drugs are manufacturing in-house in the Dublin laboratory. A Dublin-based external consultant with Qualified Person status is employed to release the material. At this stage the company again uses the services of a small amount of analytical services companies.

At the time of reporting the company is trying to find a potential licensee to take control of phase III clinical trials and market the product. The large “big pharma firms”, none of which are located in Ireland are the most likely partners in this respect.

C3.2.2 Sources of Knowledge

During stage 1, research into the ability of agents to open epithelial tight junctions in the intestinal wall, the PI operated very much as an academic in a commercial company. His main sources of knowledge were academic journals and other academics, both local and abroad. The academics included former employers, colleagues and peers in general.

The next stage, the development of oral doses for Tab1 and pre-clinical testing, starts with selecting the existing drug for development into an oral doze (Tab1). The interview material contains no information regarding the original selection process but we do have information about how Tabpharma selected the product. The delivery technology can only be applied to particular (poorly permeable) active ingredients. The list of potential active ingredients is known. The main knowledge informing the eventual selection relates to the unmet needs in the market, the patent situation and the commercial value of the product. Some of the knowledge was embodied in the members of the founding management team. However additional knowledge was obtained through an on-line patent search (patent landscape) and informal discussions with doctors (unmet medical needs). The management team took the final decision.

As to the actual technical activities during this stage, the development scientists in the formulation and the analytical group relied strongly on their experience and embodied knowledge. Compared to the first stage, the scientist relied less on academic journals and academic peers as a source of knowledge. For solving specific problems the scientists now and then consulted members of their personal academic network (mainly local), colleagues in analytical service companies as well as on-line forums.

As regards Journals, “most of them didn’t read journals. They did not need to.” (Interview principal investigator biology group). Still, although relatively less important, journals remain a source of knowledge for the development scientists. “[The development scientists] would still keep an eye on the literature to understand if there is any new way or new research or even new methodologies, techniques to help with formulations. But mostly experience and [their] own knowledge.” (Interview Chief Development Officer). From stage 2 on, the main eye on the literature is the former PI of the biology group, now working as a professor of biology in one of the local universities and operating as an external consultant.

During stage 3, the sources of knowledge of the formulation and analytical groups remain the same. The main change relates to the clinical trials. The most important and knowledge-intensive element relates to the design of the trials, setting the analytical plan. For this the company has established a Scientific Advisory Board (SAB) made up of a combination of internal management/scientific staff and three or four external advisors. Most of the advisors are clinicians, involved in treating patients, with an experience of bringing products through clinical trials and dealing with regulatory authorities. They would typically also have (know who-type) knowledge regarding suitable CROs with experience in relation to a particular set of diseases. The external members of the SAB differ from project to project.

Users, as in patients or patient groups, played no role during any of the stages. However, if we consider the clinicians as the users than these obviously constituted a very important source of knowledge during stage 3.

C3.2.3 Finding Partners

The first stage of the research, in relation to the drug delivery technology supporting Tab1, was conducted by Firstpharm independently. During the second stage research, the development of oral doses for Tab1 and pre-clinical testing, the project again involved almost no external partners, at least in the initial period when the project was still in the hands of Firstpharm. This was due to the specific business strategy in relation to Tab1. At least one other product was developed in partnership with an external US biotech firm. The initial contact was made coincidentally. The CEO met the partner company during a St. Patrick’s Day celebration in the USA.

With the transfer of the project to Tabpharma, the smaller company necessarily relied more on outside services. This tends to involve general service providers identified through industry directories or through referrals. “We would have a list of a few. [Others] are under the umbrella of a big group so a large group could have laboratories in four or five countries so we would contact the umbrella group and say do any of your labs have this method for this drug and start from there. But we would also just use the internet” (Interview analytical scientist)

During stage 3 the most important external partners are the clinicians, hospitals and the CROs. The initial clinicians that are part of the SAB were identified on the basis of the embodied knowledge of the founding management team, notably the chief scientific advisor. The SAB, in turn, identified the relevant trial sites, clinicians and the CROs.

C3.2.4 Mode of Knowledge Exchange, Proximity and Level of Intentionality

Firstpharm conducted the first stage research, into the drug delivery platform supporting Tab1, independently. The main sources of knowledge of the PI were academic journals and other academics, both local and abroad. The academics included former employers, colleagues and peers in general. Contact served nearly exclusively the formulation of ideas / and hypotheses. “You might run it by them and say well, what about this as a model or what about using drugs to open junctions? […] What do you think of this? Is this bonkers or not?” (Interview former PI biology group). Knowledge exchange with peers or former bosses abroad occurred both over the phone and face-to-face, during conferences. Knowledge exchange with the local academic network occurred face-to-face or over the phone (during the pre-Internet age).

The PI does appreciate the value of face-to-face communication and that this is facilitated by proximity. However, the PI down-played its overall importance. The research unit of Firstpharm, located on the grounds of the university was close to many academics. But face-to-face contact with local academics was limited. “It is not as big as you would think though. The interaction isn’t as huge as you would think. […] Firstpharm was a complete outsider in Trinity.” (Interview former PI biology group). This may have had something to do with the commercial aspects of the project and the related confidentiality issues. “I would have talked to people at UCD [a local university] who I would have been in the same field as but you couldn’t tell them everything because you are under confidentiality”

The next stage, the development of oral doses for Tab1 and pre-clinical testing, starts with selecting the existing drug for development into an oral doze (Tab1). The selection process is informed by a single face-to-face discussion with a small number of clinicians in different global locations. Given the particular business model for Tab1, this second stage did involve almost no external partners. The interviews did provide information about the knowledge exchange in projects that do involve an external partner wishing to develop an oral dose for its active ingredient. The initial contact with the US partner developed coincidentally. The CEO met the partner company during a St. Patrick’s Day celebration in the USA. This was followed by an introductory visit to Dublin to introduce the company and face-to-face business meetings to determine the scope of the project and commercial agreements.

The partnership did involve a substantial level of collaboration involving a cross-institutional project team of 15 people. Not all people had an active role in the collaboration though. “Anytime we had a video conference there would be like 15 of them and you would ask, oh my god, how do we do work with these people, who are these people.” (Interview analytical scientist). The collaboration involved a substantial amount of communication and knowledge exchange. Most of this was organised using email, phone and a monthly video conference involving the whole team on both sides. In addition, the project involved regular (approximately bi-monthly) face-to-face contact involving two or three Tabpharma staff. These meetings focused on project co-ordination and reporting issues. Scientist did occasionally work shoulder-to-shoulder with staff in the partner’s lab, mainly to solve specific problems. Face-to-face contact was considered important for trust building.

Most of the formulation and development work in relation to Tab1 was done in house. The development scientists involved relied strongly on their experience and embodied knowledge. To the extent that they consulted academic peers, this happened face-to-face during a yearly international conference. In order to solve specific problems, the scientists occasionally consulted on-line forums or colleagues in their personal/corporate networks either by phone or email. To the extent that they needed knowledge from journals, these were accessed from on-line sources and saved as PDF-files on the company's server. After taking over the project, Tabpharma did use slightly more external contractors, notably for analytical services. All but one of these contractors were located abroad (including US, Canada, UK and Europe). The service involves very limited communication. The initial audit involves a site visit. After this all test results are communicated by email and phone.

Partner choice appears insensitive to distance decay. Although not even relevant to the case of Tab1, partners bringing in their active ingredient for development are all located abroad. There are simply no potential partners located in Ireland. But even if this had been the case, their location in Ireland would have been of little relevance. Although face-to-face contact is considered very important, notably for trust building, this contact can efficiently be organised using long distance travel. "It is actually not an issue because (…) it doesn't matter to me where the information or where the expertise is. I prefer not to fly a trans-Atlantic flight but certainly now around Europe you wouldn't think twice about having an expert or another company anywhere else. [It is] not an issue, so we get on an aircraft and just go there. So that runs for any external people we would have. I mean we have a regulatory advisory company that we just started working with who are local here in Dublin you know but if I needed to speak to that person and they were in London, it actually doesn't matter to me." (Interview Chief Development Officer). The actual development activities involved limited shoulder-to-shoulder collaboration and to the extent it did occur it may not have been necessary. "I think there was one guy in particular who used to come a lot and I think he linked in with the formulation group so he may have provided insight. But that might have been more to do with his personality than his remit on the project" (Interview analytical scientist).

In relation to the contractors of analytical services, again, partner choice appears insensitive to distance decay with most contractors located abroad (including US, Canada, UK and Europe). The choice tends to be driven by the fact that the contractor already developed a validated method for the analytical test required.

Within Tabpharma, the internal formulation and analytical groups have their own laboratories and scientists are seldom involved in shoulder-to-shoulder research. Yet, there is a large amount of communication to co-ordinate the activities. The project team meets on a weekly basis to discuss progress. Apart from this, there is daily communication, both face-to-face and by email.

At the start of the third stage the company needed to design the analytical plan for the clinical trials. This was done in a face-to-face meeting of the Scientific Advisory Board (SAB) made up of a combination of internal management/scientific staff and three or four clinical external advisors from different parts of the world. Subsequently the Chief Scientific Officer had face-to-face meetings with the selected trial clinics,

clinicians, regulatory authorities and clinical research organisations. After this the co-ordination of the trial work is conducted mainly by the CROs. The Chief Scientific Officer is in regular communication with the CROs to discuss progress and issues. This tends to take the form of weekly to monthly video conferences but depending on the issues can also involve face-to-face meetings. The data and results are transferred by email. The selection of the CROs is driven by the location of the trials and the experience of the CRO in relation to a particular set of diseases

Most knowledge flow is intentional. The interviews provided little evidence of unintentional knowledge flow that significantly influenced the innovation project.

At Tabpharma, the use of digital environments for external knowledge exchange is limited to the email and the WWW. The WWW provides a number of resources to search the relevant literature and subject/discipline specific (international) forums. The company does not use proprietary systems to organise the communication with external partners. Internally, the company uses a server-based system to file documents, including journal articles, centrally. Electronic communication is conducted through email.

C3.2.5 Importance of the Region / Ireland

Tabpharma took over a dormant laboratory on the grounds of TCD, originally established by Firstpharm. Firstpharm located its R&D laboratory here in 1990. The interviewees suggested a number of possible reasons. It would be a good location to attract research staff. It would support contact with the academic community and related knowledge spillovers. A location on the campus of one of the country's main universities would also augment Firstpharm's credibility as a research-based pharmaceutical company. The proximity of the main international airport would make it easier for partners and customers to visit the company.

However, in reality few staff is recruited directly from the Trinity graduate programs. The education programmes at Trinity are not really suitable for Tabpharma's work. In addition, Tabpharma typically does not recruit students because they are looking for people with a level of experience. The pool of R&D staff in the greater Dublin Area was however an important advantage. Tabpharma employs highly qualified staff with 20 of the 25 staff holding a Masters or PHD and the company was able to recruit a large part of this staff from the Greater Dublin Area. This may be related to the fact that most staff are involved in development rather than up-stream research. Interestingly, quite a few staff came from another Dublin company involved in oral formulation technology

The former PI of the biology group argues that the company had relatively limited contact with academics on the Trinity campus. "It [face-to-face contact with academic staff] is not as big as you would think though. The interaction isn't as huge as you would think. […] Firstpharm was a complete outsider in Trinity. I never was convinced that they were any better there than on a green field site in [one of the suburbs]." Having said that the campus location had given rise to at least one research project (unrelated to Tab1) involving a Trinity academic research group. The initial contact was facilitated by proximity. "The program possibly might not have happened if [the professor] downstairs had not been there. So you meet them, (…) then we

would identify a potential for collaboration. In 2008 the company also sponsored a research lecturer in the school of Pharmacy and Pharmaceutical Sciences of Trinity, primarily devoted to research into novel drug delivery systems.

Much of the development work during the research project was conducted in-house. Of the external actors, virtually all service providers, clinical advisors, CROs, and sources of knowledge related to the development of Tab1 are located outside the Dublin Region, and indeed the Country. All potential customers/partners in relation to other products are located abroad. Less than a handful of persons providing contract consultancy services are located in Dublin while one of the analytical service providers is located elsewhere in Ireland.

Because the main end-user markets are in the US and Europe, the most important regulatory institutions such as the FDA are in these locations as well. This partly explains why the CEO and the Chief Scientific Officer are based in the USA, rather than in the main research unit in Dublin. The Irish Medicines Board only comes into the picture because it needs to accredit and provide a Good Manufacturing Practice licence for the small scale manufacturing activities that feed the clinical trials.

The regional biotech cluster and sectoral system of innovation is still in its infancy. Tabpharma is weakly embedded in local networks of formal and semi-formal associations. The industrial promotion agencies have developed specific web-sites and networking tools but Tabpharma makes no use of these. The company has of course strongly benefited from the government policy in the area of science, technology and innovation, notably the growing funding of third level education and research, notably in biotech related sciences. Apart from this the company benefited from the investment capital provided by Enterprise Ireland, the national industrial promotion agency. This agency also funded the collaborative research project involving Tabpharma and a Trinity academic research group mentioned above. The fact that quite a number of experienced staff came from a similarly specialised biotech company in the Dublin area may be interpreted as evidence that the company is benefiting from labour market related clustering advantages.

C3.3 TYPE OF KNOWLEDGE CREATION

During the first stage, research into the ability of agents to open epithelial tight junctions in the intestinal wall, the analytical mode of knowledge creation clearly dominates. Although the ultimate aim of the research is to provide knowledge that will inform the development of oral doses, at this stage the research was relatively blue sky. “I wasn’t sure this was going to be of real benefit to Firstpharm at any point but it seemed to me that this was a project that could eventually yield some benefit and you have to start somewhere.” (Interview former PI biology group) Knowledge creation during this stage of the innovation trajectory is concerned with unravelling the mechanisms of transportation across the intestinal wall and the proteins involved.

The research project started with the idea that the absorption of poorly soluble active ingredients can be enhanced by opening the tight junctions in the intestinal wall. This idea was inspired by the researcher’s background in ion transport in the lung and a literature review. One paper described the mechanism of ion transport and the PI

decided to apply this knowledge to enhance the transport of drugs. The research project continues with hypotheses about the role of different agents in the opening of the junctions. These hypotheses are subsequently tested in theoretically inspired research experiments. The research experiments themselves tend to be highly formalised, using highly codified models from journal articles. The knowledge output is codified as well, included in patents and published in journal articles. Although, given the commercial context, Firstpharm was reluctant to publish material before it was patented.

The second stage, the development of oral doses for Tab1 and pre-clinical testing, includes a range of activities with different characteristics. The overall aim is to develop a new technical system. The development of a practical and reproducible solid dosage form has proved an impediment to reaching commercial success in the industry. The pharmacists in the formulation group first develop an unsophisticated formulation for use in pre-clinical studies. The challenge lies in advancing a preclinical concept to a marketable formulation that can be used in human patients. The pharmacists in the formulation group worked for about 6 month developing a recipe for an oral tablet that combines the active ingredient with the enhancer system. Based on analysis of the characteristics of the active ingredients the pharmacists work from a central assumption about the amounts required. This is based on codified knowledge developed in-house. The codified nature of the knowledge is illustrated by the way the knowledge was transferred from Firstpharm to Tabpharma. “By the time the deal was done in 2004, there was nobody left here. So there was boxes of data (…) There was patents and boxes of data basically”. However the process involves a strong element of trial and error or tweaking. “Then, the next thing is you try the different recipes and it’s a little bit more this, little bit less of this, until you come up with something that you think is” (Interview Chief Development Officer).

The formulation work is supported by the analytical chemists in the analytical group that are responsible for developing the tests used to determine the physical characteristics of the drug and during the pre-clinical trials and clinical trials as well as actual conducting (a small number of) the tests. Conducting the tests involves clearly an analytical mode of knowledge creation. Knowledge inputs and outputs are strongly codified. The tests are highly formalised, based on protocols (developed in-house). However, the main challenge and most of the in-house activities lie in the development (creation) of the tests. This activity involves a combination of codified and tacit or experiential knowledge. It is partly based on protocols partly involving trail and error and tweaking. Overall this stage is best characterised as a combination of a synthetic and an analytical mode of knowledge creation.

The final phase, clinical trials, is dominated by the analytical knowledge base. The activities do not change the actual oral dosage. It is about gaining further understanding regarding its efficacy and testing the hypothesis about the efficacy. The trials are following (codified) protocols laid out in the analytical plan set at the start of the trials by the strategic advisory board and strongly determined by the regulatory requirements. The (codified) analytical tests are developed in the preceding stage by the analytical group. The knowledge outcome is of a purely codified nature. “The key thing is at the front end of the clinical trial … here is the data we are going to collect and then [the Clinical Research Organisations] design the database but the actual analytical plan is set at the beginning of the study so at the end basically they plug

[the data] in to the tables and then the analysis should flow from that." (Interview Chief Development Officer)

After focussing on the relevance of the analytical/synthetic knowledge base and mode of knowledge creation it is important to point to the importance of a specific *type* of knowledge in the innovation trajectory – market or industry knowledge. During stages 2 and 3 important challenges relate to selecting the right active ingredient for further development and stetting the analytical plan for the clinical trials. Solving these challenges requires knowledge of the market and industry, including know who type knowledge and connections (e.g. with clinicians) rather than scientific or technical knowledge. This is partly reflected in the competences of the original management team that, apart form a background in science, all had a strong commercial/industry experience. The CEO had recently worked at a venture capitalist company and had conducted the due diligence of the Firstpharm assets. The Chief Operations Officer had 20 years experience in the business development and marketing aspects of the pharmaceutical industry. The current Chief Development Officer had a background in clinical development and project co-ordination/planning

At the start of stage one of the main reasons to consult external clinicians was to get their opinion regarding unmet medical (market) needs. At the start of stage three, the external members of the scientific advisory board are primarily selected on the basis of their experience with bringing products through clinical trials and dealing with regulatory authorities. In addition, they add important know who-type knowledge regarding suitable CROs with experience in relation to a particular set of diseases.

Table C3.1 summarizes the information regarding dominant knowledge bases and links this to the location of actors, the sources of knowledge and the salience of face-to-face contact between institutions

Table C3.1: Modes of knowledge creation, location of actors and intensity of face-to-face contact – biopharmaceutical drug project

	Dominant mode of knowledge creation	Location Actors	*Sources of knowledge (in order of importance)*	*Inter institutional face-to-face contact (frequency and number of people involved)*
1) Research into the ability of agents to open epithelial tight junctions in the intestinal wall	Analytical	Ireland (internal)	Academic journals (at that stage no e-journals) members of the scientific community in general	*Global: multiple times a year (conferences)*
2) Development of oral doses for the drug and pre-clinical testing	Synthetic/ Analytical	Ireland (internal) US, Canada, UK, Europe including one in Ireland (routine analytical services)	*For technical activities:* Academic journals (to a lesser extent compared to stage 1) Members of the scientific community in general (to a lesser extent compared to stage 1. Some in the form of on-line forums) *For sector/industry knowledge* Members of the founding team External clinicians e-Journals Patent database (on-line)	With academic peers Global: once or twice a year. (all development scientists) Local: n.a. With analytical services companies Global and Local no f-t-f contact
3) Clinical Trials	Analytical	Ireland (Internal) US and Europe (CROs) US, Canada, UK, Europe including one in Ireland (routine analytical services) Possibly US, UK or Europe (pharma client)	*For technical activities:* Academic journals (to a lesser extent compared to stage 1) Members of the scientific community in general (to a lesser extent compared to stage 1. Some in the form of on-line forums) *For sector/industry knowledge* Members of the founding team External clinicians (as part of the scientific advisory board) CROs	With analytical services companies Global and Local no f-t-f contact CROs Global: monthly (Chief Scientific Officer only)

C3.4 THE ORGANISATION OF KNOWLEDGE COMMUNITIES AND CENTRAL OCCUPATIONAL GROUP

C3.4.1 Occupational Groups

The dominant occupational groups are within the biosciences themselves. The main division here is between the formulation scientists and the analytical scientists. Both are founded in chemistry and biochemistry and the relations between them seem to be relatively easy.

Although there are external testing organisations, these do not shape the internal workings of the project and/or firm to any great degree (as in case 1). It is interesting that there is little mention of the end users or the markets for these drugs. This may be because the end market of many products that Tabpharma is creating is other pharma companies so that both producer and user companies share similar 'knowledge cultures' and learning about how users operate is not a major challenge for Tabpharma as they are embedded within the same culture.

C3.4.2 Heterarchical and Hierarchical Knowledge Flows

The knowledge flows in this case are both the most straightforward and the most contested. They are among the most straightforward because there appears to be a strong shared scientific-technical culture. This is rooted in the technical user market; the focused organisation of the company around the formulation and analysis of existing, clearly defined IP; the shared disciplinary background of the key scientists. There is relatively little evidence of heterarchical knowledge flows, unlike other cases where different knowledge communities are brought into dialogue with each other.

However, there also appear to be greater tensions in negotiating information flows even within this shared knowledge community. These are partly around the negotiation of IP and competition with Firstpharm itself. These discussions indicate that IP provisions never completely define the boundaries of who owns what knowledge and has the right to dispose of it in particular ways. The IP that Firstpharm sold 'fixed' a particular definition of a particular bit of knowledge that belonged initially to the venture capital company and then to Tabpharma. In that sense, the knowledge embodied in the IP was detached from its own history and the social relations within Firstpharm that had created it – and that contained a richer understanding of the knowledge than is ever completely specified in the IP itself. But that knowledge in the area continues in its own trajectory with ongoing tensions between individuals and between Tabpharma and Firstpharm regarding information sharing about how the development of drugs in each company is going, the results of tests, the availability of information about what has worked and hasn't worked in development and formulation processes, and so on.

This is also, however, linked to the corporate culture of Firstpharm which appears quite different from the other companies we have examined. In case 1 and 2, a core group of founders and senior scientists formed a cohesive team that held together what were relatively small companies. Even in the focal company of case 1, which had a more diverse and complex organisational structure than the unusually small and cohesive focal company in case 2, the social relations among the core team helped to

facilitate consensus building across different divisions and levels (e.g. between the Board, the Scientific Advisory Board and the project teams). However, the Firstpharm organisational strategy appears to have been the opposite of this – emphasising open conflict over consensus as a mode of arriving at the best decisions. While this may have had advantages in the operation of projects, it does seem to have contributed to a broader organisational culture where there appears to have been less easy information sharing than within the other companies. In addition, Firstpharm appears to have had a more aggressively commercial orientation than the other companies which remain more deeply embedded in the academic scientific community. It is not clear to me exactly how this shapes Tabpharma.

C3.4.3 Organisation of Knowledge Communities

This case is somewhat different from the others as the company is much less highly networked than the other companies we have studied. The main external ties are to clinical and analytical services organisations (similarly to the later, development stages in case 1).

This is at least partly because of the history of the company as a kind of 'spin-off' from an earlier, larger company that developed the IP which the company is using. The structure of the new smaller company is much more self-contained than the other case study companies. However, the conclusions of the analysis are in many respects the same as the extensive networks in to academic communities and with other biotech firms are largely characteristic of the research phases of projects and company development. Part of the reason for the relatively restricted networks of the company are that this company is largely involved in the formulation (and subsequent testing and analysis) into drug form of science that is largely contained in the IP that was separated from Firstpharm when the company ran into difficulties.

In that sense, there is an 'artificial separation' of the research and development parts of the project, driven by the legal and commercial 'break point' of the sale of IP to venture capital and the constitution of this new company to further develop it. This is also somewhat evident in the tense relations with Firstpharm and the absence of the kinds of informal communications between the initial research team and the formulation and analytical scientists. There is also little or no information sharing between the teams at Tabpharma working on developing the drugs and the scientists at Firstpharm that are also continuing to work on the development of drugs based on this, or related, science.

Nonetheless, it is interesting that the process still draws on connections to the university. The company is located within the university and various parts of the interviews emphasise the strong informal connections to others in the university – partly for access to the formalised theoretical knowledge, partly for the general scientific knowledge that is crucial to even the more 'logistical' elements of the development phase, and partly for the kinds of scientific 'know how' (or the 'craft' of science) that also exist within the university (and are often overlooked in the emphasis on formalised knowledge). Being based on campus provides access to the social world of the university in ways that those in other institutions (especially those in lower status positions) find more difficult - the ability to be part of the everyday conversations over coffee and access to prominent researchers being among them.

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C3.5 ORGANISATION OF FIRMS AND MARKETS

C3.5.1 The size of firms

Over its life time the innovation process has involved a relatively small number of actors. An important part of the IP was developed internally by Firstpharm, a medium-sized biotechnology company. The IP was divested and acquired by a small dedicated biotech company who conducted most of the development work in-house. Stage three sees the entrée of number large CROs, responsible for co-ordinating the specialised clinical trial work. The strategy is to licence the product to a large multinational pharma company after successful stage II clinical trials.

In an industry characterised by long development times and high capital requirements, Tabpharma has adopted a business model that allows it to operate and grow as an independent firm. It operates a low risk approach to development. With the platform technology already developed secured by IP the company can expect a relatively quick return on investment. The company focuses on oral doses for products which are already proven on the market. This reduces the regulatory requirements, time to market and finance required. Still, the development of oral doses requires a substantial investment and risk. To further reduce the risk the company operates a mixed model with multiple products in development. Some of these are developed independently with the aim to out-licence the product at stage III clinical trials (e.g. Tab1). Others are developed in partnership with pharmaceutical companies where Tabpharma receives regular payment from the partner to finance the development costs.

C3.5.2 The age profile of firms

Tabpharma is a very young (5 years) dedicated biotechnology firm specifically established to exploit existing intellectual property. Some products it develops mainly in-house. After phase II clinical trials the company will out-licence the product to a long established “big-pharma” firm. With other products, long established pharmaceutical companies are involved from the start.

However, it is difficult to understand Tabpharma’s structure and development without understanding its history as an outgrowth of Firstpharm, via the sale of Firstpharm’s IP, and the influence of Firstpharm’s corporate culture (at least to some extent).

C3.5.3 Type of user markets

The eventual end users are patients with a particular disease, often organised into representative associations and foundations. However the main “customers” of the drug are the medical professionals and healthcare organisations. When the innovation trajectory moves from gaining an understanding of biological absorption mechanisms to the development of oral doses of drugs, these clinicians get involved and give their opinion regarding the feasibility of the project. Their ideas regarding the unmet medical (market) needs and the size of the market played an important role in steering

the innovation project. Later the same clinicians and hospitals play an important role in designing and facilitating the clinical trials. The actual end-users, the patients and the patient associations play a very limited role, at least until the phase III clinical trials.

C3.6 INSTITUTIONAL CONTEXT

C3.6.1 Associational Networks

Tabpharma is relatively weakly embedded in networks of formal and semi-formal associations. For the important contacts with clinicians in academic institutions the company relies on the personal and professional networks of the Chief Scientific Officer and the external members of the Scientific Advisory Boards. Recently the company is developing links with different actors in Trinity College, where it is located. This includes a research project involving a Trinity academic research group and the sponsoring of a research lecturer in the school of Pharmacy and Pharmaceutical Sciences, primarily devoted to research into novel drug delivery systems.

The company has formal links with the national industrial promotion agency, Enterprise Ireland. This agency took a small stake in the company and provided some of the initial capital as part of a scheme to support new company formation. However, EI is not actively involved in the management or governance of the company. In addition, more recently EI funded a new collaborative research project involving Tabpharma and a Trinity academic research group.

Tabpharma is not embedded in any national or international trade or industry organisations. EI has organised an online networking facility for the biotech industry (Biotechnology Ireland) but Tabpharma makes no use of it.

C3.6.2 Forms of regulation

Bringing the innovation from the inception of the idea to the market takes a very long time and involves great costs and investments. In this particular case the initial discovery work started in the 1990s and Tab1 will not be on the market before 2011. This high level of investment in time and costs is to a large extent driven by the intense level of regulation. However, it is not until the last stage of the innovation process, the clinical trials, that regulation starts to significantly influencing the innovation process and the knowledge flow.

Clinical trials are intensely regulated by national and international regulatory authorities. The Irish Medicines Board provides the important accreditation to produce drugs for use in the clinical trials. Marketing a drug requires a licence from the separate national regulatory authorities such as the FDA in the USA. The related trials and communication of the results are highly formalised. The involvement of human subjects and clinicians makes phase three trials very time-consuming and costly. However, Tabpharma focuses on the development of oral doses for products which are already proven on the market. This reduces the size of the trials, time to market and finances required relative to the development of an entirely new drug.

Still, the development of oral doses requires a substantial investment and risk. To further reduce the risk the company operates a mixed model with multiple products in development. Some of these are developed independently with the aim to out-licence the product at stage III clinical trials (e.g. Tab1). Others are developed in partnership with pharmaceutical companies where Tabpharma receives regular payment from the partner to finance the development costs. The chosen business model means that the company can continue to operate and grow as an independent company.

C3.6.3 Finance

Bringing the innovation from the inception of the idea to the market will take at least 20 years. The initial delivery platform research started in 1990s and Tab1 will not be on the market before 2011. With the delivery technology platform largely developed, Tabpharma could expect a relatively quick return on the investment but it would still take at least 10 years before the company would start to get revenue. Hence the project required a substantial capital investment and given the risk involved venture capital was the most obvious route. The initial capital to acquire the IP assets was financed through a loan from the Venture Capital group. As part of the deal Firstpharm obtained a minority share in the company and 10% royalty on any revenue related to the IP. Subsequently the company secured further funding in a second round from other venture capital sources, and Enterprise Ireland, the national industrial promotion agency, which took a small stake in the company. None of the external financiers appear to directly influence the innovation trajectory of Tab1.

The greatest investment is required during the phase three clinical trials. Given the fact that the active ingredient is already on the market, the size of the trials and the required finance will be smaller than would be the case with a completely new active ingredient. Still it will require substantial funds and the business model is to partner with one of the global big pharma companies to finance this stage of the innovation trajectory or to out-licence the technology at this stage. The chosen business model means that the company can continue to operate and grow as an independent company.

10 CASE STUDY 4

DEVELOPMENT AND PRODUCTION OF A COMPUTER ANIMATED CHILDREN'S TELEVISION SERIES – (DUB ANIM)

C4.1 OVERVIEW

This case study concerns the development and production of a 3D computer animated children's' television series (52 episodes) targeting a pre-school girls audience. The series is based on an award-winning children's book series about Eppie, a young animal that believes she can do anything. The innovation trajectory of an animated television series includes four stages: development, pre-production, production and post-production. Every episode involves a sequence of pre-production, production and post-production, although the amount of pre-production work gradually reduces. In addition, there is an element of overlap between the stages where problems in the post-production stages may require further production and even pre-production work.

The development stage is partly a creative stage and partly about business development. Typically a producer will identify a theme based on an existing book or original idea and prepare a synopsis, often containing drawings to help visualise the key points. A key element of development is securing finance and attracting clients for the series. In the case of Eppie, the book series was originally published in 2000 by an international book publishing company. The rights to turn the book into an animation were acquired by CoDis, a British multinational media and brand development company. CoDis found a partner and initial client in BroadChild, a US children's television channel, who commissioned a series of 52 episodes for the US market. Subsequently, CoDis put out an international tender for the animation production. The tender was won by Dub Anim, an award winning Irish animation company, located in Dublin. Dub Anim received a service contract involving a payment for animation services. It was not involved in securing the finance for the production. From this perspective it was not a co-production. However, the company was paid to be involved in the creative development process from a very early stage.

In October, 2007, with the finance in place, the project moved into the pre-production stage. At the start of the pre-production a team of script-writers at CoDis develops the scripts for the episodes and organises the voice recordings. Dub Anim takes this material and starts a creative process of "deciding on the look and feel of the show" involving character design, character modelling, story board development, and animatics (see below). The work for the first episodes took two months but pre-production is an ongoing process with new episodes requiring additional work. In December 2008 the first episodes went into the production stage. Production is a relatively less creative stage of translating the template, or pre-production pack, into an actual movie. "It is very prescribed, in that there is very little room for creativity or input from [the animators]. It is basically an exercise in joining the dots." (Interview Managing Director / Executive Producer). This work was contracted out to an animation company in South Korea. But the activities were tightly organised and

controlled by Dub Anim, who employed one person to oversee the project on-site. The Korean company produced several versions/iterations of an episode, integrating the editorial comments of Dub Anim.

Post production, the final stage of creating a 3D computer animated TV series was done by Dub Anim in-house. It is editing the production work and creating the final episode by adding or perfecting additional effects such as sound, music and lighting. The editorial process involves several formal stages with the co-producers and broadcasters providing their ideas and comments. The first episode was aired in the USA in January 2008 at which time CoDis had already established sales with six other broadcasters in Europe and Australia. In addition, the company was developing a licensed product program in all major areas to further exploit and develop the brand.

We distinguish four different stages in the innovation trajectory.

1 Development
2 Pre-production
3 Production
4 Post-production

C4.2 PATTERNS OF KNOWLEDGE FLOW AND INNOVATION

C4.2.1 Type of Actors and their Location

The original book was created by a USA based author and published by an international book publishing company. But the development and creation of the animated computer animated children's television series really only started during the development stage. This initially involved the producer, the New York office of CoDis, a British multinational media and brand development company and the initial client, BroadChild, the US children's cable television broadcaster. At an early stage Dub Anim, a relatively small (50 staff) award winning Irish indigenous animation company, located in Dublin, enters, effectively acting as the animation producer. Most of the actual development work is done by CoDis and Dub Anim although the broadcaster has an active involvement in the decision-making regarding the content of the series. The collaboration between CoDis and Dub Anim involves a clear division of labour with CoDis responsible for the commercial aspects of production as well as dealing with the script-writers and broadcasters and Dub Anim focusing on the animation/content. Within Dub Anim most of the creative development work at this stage was carried out by the director and art director. Throughout the remainder of the innovation process the broadcaster's role remains the same, commenting on work at different stages in the development of episodes to ensure that the product is suitable for its target audience.

In the pre-production stage the institutional actors remain the same. CoDis, was the actual producer. On top of that the company organised a team of scriptwriters and organised the voice recordings. Dub Anim is responsible for the animation production, involving character design, character modelling, story board development, and animatics. Internally, in Dub Anim, about 20 staff members are involved in Eppie, organised in different teams. Overall creative responsibility lies with the Director who is assisted by the Art Director and Technical Director. He directs staff

members with specific skills organised in different teams including a modelling team, an animation team, a lighting team, sound, and a group of editors. A single Production Manager liaises with the different teams. Although CoDis was the actual producer, Dub Anim employed its own "internal producer" whose role it was to make sure that that the animation production stayed on schedule and on budget. This team remains in place for the entire innovation trajectory, including post-production although the intensity of the involvement of internal and external actors differs from stage to stage.

In the production stage of individual episodes, Dub Anim outsourced the less creative activity of animating the pre-production pack to a small, recently established, animation studio in South Korea. Dub Anim was familiar with the founder's previous work. The activities do not involve any shoulder to shoulder work by staff of the two companies but the activities are tightly organised and controlled by Dub Anim, who employed an overseas supervisor who acts as "a production manager on the ground". Finally, most of the activities in the post-production stage are conducted by the Dub Anim production team, integrating comments from both CoDis and the broadcaster.

C4.2.2 Sources of Knowledge

The main actors during the development stage were CoDis, the multinational media company and main production company for Eppie and the animation company Dub Anim. We have no information regarding the knowledge sources of CoDis. Although Dub Anim was not involved at the start of the development stage, it did get involved in the creative development work at very early stage. In addition, we can learn from Dub Anim's experience with from developing other projects.

In Dub Anim all staff is encouraged to come up with ideas for new projects. These ideas are distilled by a small group of senior staff, including the two founders, the arts director and the director of development. A small development team is responsible for investigating the merits of possible projects and subsequently pitching projects to the executive producer/founder. The sources of ideas are varied. "The ideas come from everywhere. There is no fixed source of ideas: it could be somebody's portfolio, it could be an ad, it could be a TV program, or a webpage - it could be anything that just gives you an idea to do something different. In that sense there is no science to where we get our ideas from - they just come from random places." (Interview Managing Director / Executive Producer) "You would look at trade journals, TV schedules, you would watch kids playing […] you would really throw the net wide. […]For example, when you are in an airport, you would wander in to bookshops and see which children's books they stock […] you would watch kids playing with toys, what are they doing. All these situations give you an impression of current trends in the market. You would see what is hot, what are broadcasters buying […] you would even get inspiration from just the computer games or TV shows that you like to watch. It is a lifestyle" (Interview Creative Director) Dub Anim focuses on children's programmes and the decision-makers need to keep themselves informed about their audience. Initial ideas get tested by the target audience. For this the company visits primary schools and play groups where children are asked for their opinion regarding a particular book or video.

In relation to developing the first designs of the characters of the show, the company would rely on similar sources as discussed under pre-production (see below). In addition CoDis and the broadcaster played an important role in the process,

commenting on the initial designs and providing ideas to make sure that the eventual design would be in line with the overall brand development process and would be suitable for the audience.

Know who type of knowledge is particularly important during the development stage. A lot of this is embodied in the two founders and the small development function of the company. The team is extremely well networked due to its previous international animation and production work. “We would know all the broadcasters in the world that deal with children. [We deal with them] on a first name basis. To supplement the know who type of knowledge the company regularly attends and presents at the large scale annual or bi-annual international trade fairs and conferences, notably MIP TV, KidScreen and Cartoon Forum.

During the pre-production stage the artists rely to a large extent on their embodied knowledge and artistic imagination. In addition the artists rely on a multiple sources of information. Many of the above mentioned sources of knowledge or inspiration are relevant here as well, notably watching DVDs and looking at children. For more focused challenges, artists rely heavily on publicly available images. The artists do a lot of on-line research. “For the movement of the character, for example, there’s an episode where [the animators] are doing ice-skating, and so we looked online at children playing hockey and the way they sometimes wobble and have a slightly off-balance movement. […] There are numerous YouTube references for these types of films.” (Interview Creative Director). Most of the knowledge is assembled by the director, arts director and other senior artists and communicated to the animators.

Dub Anim obtained some ideas from CoDis and the broadcaster as part of the formal editorial process. The broadcaster may have issues with the content of the show. In addition, the co-producer may have comments and communicate suggestions and references regarding their ideas. Apart from this staff at Dub Anim do not consult external persons for knowledge and inspiration.

The production and post-production stages are more prescribed with less time for creativity. “It is more about thinking on your feet during production really, it’s not something you have a lot of time to work out, and you really have to go with instinct a lot of the time.” (Interview Creative Director) The directors rely on their internal staff and their own embodied knowledge and ideas to find solutions for particular problems.

C4.2.3 Finding Partners

During the development phase CoDis asked a number of international animation companies to tender for the animation production work. Dub Anim was approached on the basis of their international reputation in children’s animation. The company had a relatively high profile due to international awards for previous work, including an Oscar nomination. In addition Dub Anim’s development group is well networked due to its previous international animation and production work. “We know all the broadcasters worldwide that deal with children’s animation. [We deal with them] on a first name basis. The company regularly attends and present at the large scale annual or bi-annual international trade fairs and conferences, notably MIP TV, KidScreen and Cartoon Forum.”

Dub Anim identified the Korean animation studio, again based on a combination of visiting trade fairs, international reputation and previous professional relations. Dub Anim's executive producer was aware of a particular individual that he wanted to work with and this person had just established his own company.

In terms of its own staff Dub Anim had difficulty finding the required numbers in Ireland and needed to recruit internationally. A substantial number of individuals were Irish return migrants that had worked in animation companies abroad. They had typically responded to Dub Anim's recruitment campaigns on animation specific websites and magazines. The international group of animators is relatively small and they tend to use the same web-sites for finding jobs. In addition, Dub Anim has visited local colleges to identify suitable staff.

C4.2.4 Mode of Knowledge Exchange, Proximity and Level of Intentionality

The main actors during the development stage were the producer, CoDis, operating out of a New York office, BroadChild US, the broadcaster and Dub Anim the animation company located in Dublin. Most of the actual development work is done by CoDis and Dub Anim although the broadcaster has an active involvement in the decision-making regarding the content of the series. The collaboration between CoDis and Dub Anim involves a clear division of labour with CoDis responsible for the commercial aspects of production as well as dealing with the script-writers and broadcasters and Dub Anim focusing on the animation element. The development stage involves a substantial amount of communication between the three partners. Communication concerns on the one hand contractual, legal and scheduling issues and on the other hand creative issues. At this stage the contractual part of the communication is handled mainly by Dub Anim's executive producer and the small development team while the creative issues are dealt with by Dub Anim's director and art director.

A large part of the communication is conducted by email, telephone and, to a lesser extent, video conferencing. In addition, there is a substantial amount of face-to-face contact moments at this stage. Most of the initial business related meetings would be conducted on a face-to face basis. The meetings are organised as short trips and some are organised to coincide with one of the international trade fairs or conferences. In addition the creative people would have several face-to-face contact moments. Face-to face contact facilitates the communication of the tacit knowledge related to the initial ideas. In addition, the face to face contact serves to strengthen the relationship and trust. "I think, ultimately, when you go and meet these people, it is important that you get along, that you are friendly with each other, and that you enjoy working with each other. Often just socializing with collaborators and discussing what they really love about the project, or what they don't like about the project. Yeah you can get inside." (Interview Creative Director)

Partner choice appears to be relatively insensitive to distance decay. To an extent this is driven by the fact that partners operating in small markets are unable to raise sufficient finance in their own market. One of the reasons to work with co-producers abroad is that this will provide the necessary complementary finance. In the case of Eppie, Dub Anim was selected exclusively on the basis of the knowledge and experience it could contribute to the series and was identified because of its

international reputation. CoDis was well informed about the relevant international players mainly due to experience in previous projects and by visiting trade fairs and conferences. The development stage involves a substantial amount of face-to-face contact moments but these can be efficiently organised through frequent short-term visits, some of which are combined with trade fairs.

At the start of the pre-production stage the companies involved established their internal teams which remained in place during the production and post-production stages. The three stages involve a great amount of communication between the three partners. The amount of business related communication is substantially reduced and the executive producer within Dub Anim focuses his attention on new projects. Most of the necessary communication can take place by email, phone and teleconferencing. However, the communication regarding the actual animation activities intensifies. The project pipeline involves the development of characters, takes and retakes and at least four different versions of each of the 52 episodes. All the takes and versions need to be sent to the partners and the partners communicate their comments. Most of the notes are communicated by mail but the process does involve a substantial amount of discussion. The director has about three one-hour conference calls a week with the partners to go through the notes and the deliverables. Sometimes the communication is mediated through a video conferencing system which allows the participants to split the screen and pull up drawings on the screen.

These media are certainly sufficient for communicating co-ordination related issues and part of the creative issues. But is not always sufficient for communicating all the tacit creative knowledge. For this reason the creative people continue to have face-to-face meetings at key points during the project. “When the first offline started to come back maybe they would visit us, sit down with us, and we would look at them together. The first time we start dealing with sound, they would come over and we would all listen to it together, so we would all know that we were hearing it from the same source. […] We could then discuss it and ensure that we all heard it in the same context. It is good to have face-to-face contact for this.” (Interview Creative Director)

Working with the Korean animation studio during the production stage, again involves a substantial amount of communication. Here too, Dub Anim receives several versions of takes and retakes and each time Dub Anim communicates its comments. The Korean activities are far more prescribed and the knowledge input more codified in the form of the template (pre-production pack). This is not to say that there are no issues related to the tacit nature of the knowledge, its specificity to context and the cultural, linguistic proximity/distance of the partners:

> There could be all sorts of mistakes […] say sense of humour. Like people in Korea don’t speak English they don’t understand things and when you would have something in the script or written down saying [the character] dances of joy with this … You know. Their interpretation of that could be … a Korean dancing with joy could be like you know lets put one hand in the air and walk slowly. So there is huge kind of cultural things as well so you would have to get all that redone and tell them exactly what you mean (Interview Executive Producer)

These issues are partly communicated by Dub Anim’s overseas supervisor who basically functions like a production manager on the ground, providing temporal proximity. This person vets anything that comes to Dublin. However, his main task is

one of co-ordination. The animation pipeline requires a great amount of co-ordination with the Korean studio. The co-ordination of the scheduling and numerous deadlines in the pipeline are of such importance to the company that Dub Anim chooses to have one person on the ground to oversee the project on-site. In Dublin most of the communication is handled by Dub Anim's internal producer using email and phone. The creative director of Dub Anim has almost no direct communication with the Korean studio.

Again the choice of the Korean partner appears to be insensitive to distance decay. The partner was selected exclusively on the basis of their price-competitiveness and the knowledge/skills it could contribute to the series and was identified by the executive producer on the basis of personal "know who". The executive producer and other members of Dub Anim's development team are well informed about the relevant international players mainly due to experience in previous projects and by visiting trade fairs and conferences. The production stage involves a need for face-to-face contact but this is efficiently organised through temporary proximity in the form of an overseas supervisor.

Within Dub Anim, although most individuals or teams have specific skills, the various stages involve a substantial amount of near shoulder-to-shoulder work and a great amount of communication, including face-to-face. Apart from some of the sound work, most of the other activities are conducted in an open office environment housing members from the different teams. The importance of deadlines and related co-ordination involves weekly formal meetings and daily face-to-face contact with the production manager going from desk-to desk to check progress. In addition, the work involves a substantial amount of problem-solving which requires the real-time input of members from different teams. "It involves a continuous solving of problems. There is a lot of interaction […] For example, if there's a quirk in a model and it is throwing a bad shadow the lighters need to go back to the modelling and help fix this […] on a regular basis [...]. You're literally shouting across to your colleagues in order to identify and solve these problems as they crop up." (Interview Creative Director)

Although most knowledge flow is intentional, there is evidence of unintentional knowledge flow, notably "know who" type knowledge. The international trade fairs, notably MIP TV, KidScreen and Cartoon Forum, play an important role in this. One of the main functions of such events is to meet new potential partners (co-producers and funders) and to keep informed about the relevant actors in the industry. Although the actors attend these events with the specific intention to gather such knowledge, a substantial amount of knowledge and information exchange is at least unplanned or unforeseen. Further (partially) unintentional information exchange of know who type knowledge is mediated by trade journals, websites and internet forums.

In addition, some of the inspiration type knowledge is exchanged at least in a partially unintentional fashion. "The ideas come from everywhere. There is no - fixed source of ideas: it could be somebody's portfolio, it could be an ad, it could be a TV program, or a webpage - it could be anything that just gives you an idea to do something different. In that sense there is no science to where we get our ideas from - they just come from random places." (Interview Managing Director / Executive Producer) You would look at trade journals, TV schedules, you would watch kids playing […] you

would really throw the net wide. […] For example, when you are in an airport, you would wander in to bookshops and see which children's books they stock […] you would watch kids playing with toys, what are they doing. All these situations give you an impression of current trends in the market. You would see what is hot, what are broadcasters buying […] you would even get inspiration from just the computer games or TV shows that you like to watch. It is a lifestyle" (Interview Creative Director). This quote suggests that for the knowledge inputs and inspiration, the creative staff needs to be in touch with current children's culture and children in general.

Interestingly this unintentional knowledge exchange through "buzz" mainly operates at an international and/or virtual level. Local buzz appears to be irrelevant, at least for know who type knowledge[6]. All the trade fairs that are attended are international events. The potential local places of know-who-related buzz are only sporadically attended by the senior actors in Dub Anim. The executive producer visits very few local animation relevant events. "Not really, there are the occasional bits and pieces but not that much […]. I used to go to everything once upon a time. I used to attend literally every wine reception in Dublin just trying to network and meet people but now I feel I know what I want to do and I would prefer to go home early, and spend time with the kids. […] I see a lot of them anyhow at all the international trade markets I attend. […] It's all the same animation people from Ireland. *So is that international network more important then the local one?* Oh yeah, absolutely."

In relation to inspiration type knowledge, although some of the buzz operates on a local scale, substantial elements operate on an international and/or virtual scale. It is important for artists to be in touch with society and children's culture, but the relevant[7] culture for Dub Anim is Anglo-American, not local. The above mentioned trade journals, children's books (observed in airport bookshops) and DVDs are nearly exclusively international.

Dub Anim uses a number of digital environments for external knowledge exchange. Email is used extensively as a communication tool. The WWW is used to access project specific artistic knowledge and inspiration, know who type knowledge and for recruitment (some of this material is concentrated on international animation websites such as the one of *CGI Talk*, an international on-line animation community). The voice and data communication with the partners in New York is partly mediated through a Polycon video conferencing system that the partners have in common. At present Dub Anim uses an *Excel*-based project management tool for internal use but the company is in the process of installing a new software system *(MS Share Point*) that would allows for cross-institutional project-management.

C4.2.5 Importance of the Region / Ireland

The main reason for Dub Anim's location in Dublin is historic. The company was founded by two classmates from the Ballyfermot College for Further Education where they had attended animation related courses.

[6] Although, the founders knew each other from college.

[7] This hold for this specific animated TV series only. The company does conduct local TV and advertising work and in these cases they do tap into local culture.

Apart from the tax incentives (see below), the company derives few specific benefits from its location in Dublin or Ireland. In relation to the specific series under discussion, all the significant partners and markets are located outside Ireland. This holds for most other projects although the company has done work commissioned by the national broadcaster. The main sources of knowledge, both know who type knowledge and inspiration, are internal, international (e.g. trade fairs and children's books) or virtual (YouTube, on-line forums or DVDs). Dublin does play a role as a source of inspiration but the knowledge involved (children's culture and watching children play) is relatively ubiquitously distributed, at least across the Anglo-American world.

The regional animation cluster is small by international standards and the sectoral system of innovation is only starting to develop. The legacy of classical animation companies such as Sullivan Bluth[8], and the development of the third-level training and education infrastructure in the form of the Ballyfermot College and the Dun Laoghaire Institute of Art Design and Technology does provide an important source of skilled labour, but the skills base remains limited. Dub Anim experienced difficulty finding the required numbers of staff and needed to recruit internationally. A significant part of staff is made up of return migrants that have worked in animation companies abroad.

The company consciously decided to locate its new studio outside the Digital Hub, the policy led concentration of digital media companies in Dublin. Although the Managing Director acknowledges that such a location would offer synergies based on contact between staff from different companies, the benefits were not perceived to outweigh the downsides of a location in The Hub, notably the fact that The Hub is located in a relatively unsafe part of the city.

The important business networks are global in nature and the networking events are primarily international events. Although Dub Anim is well informed about the Irish animation scene, the potential local places of know-who-related buzz are only sporadically attended by the senior actors in Dub Anim. The executive producer visits very few local animation relevant events. "Not really, there are the occasional bits and pieces but not that much […]. I used to go to everything once upon a time. I used to attend literally every wine reception in Dublin just trying to network and meet people but now I feel I know what I want to do and I would prefer to go home early, and spend time with the kids. […] I see a lot of them anyhow at all the international trade markets I attend. […] It's all the same animation people from Ireland. *So is that international network more important then the local one?* Oh yeah, absolutely."

Although strongly networked in the international animation scene, Dub Anim is less strongly embedded in networks of formal and semi-formal associations. It does "help out" at a local third level institution. As a company, Dub Anim is a member of the Irish Business and Employers Confederation, the Irish Film and Television Awards (a platform to honour and celebrate Irish talent), the Screen Producers Ireland and Screen Training Ireland (a training initiative organised by the national employment agency) At least one of the staff is a member of professional associations. The

[8] Ex-Disney people established companies in Ireland in the mid 1980s. Some of these people were also instrumental in setting up animation courses in Ballyfermot College where they were also involved in teaching.

creative director is involved in the Screen Directors Guild of Ireland. The Guild was established in 2000 as a representative body for Directors involved in the Irish and international audiovisual industry. Its goal is to support Irish screen directors and promote Irish directors on a national and international scale.

Enterprise Ireland, the national industrial promotion agency does manage the *AnimationIreland* web-site. The site functions as a promotion tool and knowledge repository for the Irish animation industry. However, companies do not need to be associated to be included on the site.

In terms of finance, the company was established without substantial start-up funding from state agencies. Although the Irish tax incentives are of crucial importance to the competitiveness of the company, the main sources of finance in the form of co-producers and commissioning clients are located outside Ireland. EI has provided some financial support for visiting international conferences such as the Kidscreen summit.

C4.3 TYPE OF KNOWLEDGE CREATION

The first three stages are dominated by a symbolic mode of knowledge creation although its level of dominance diminished with each stage. The creative innovation of the project lies in translating a 4-series book into a 52-episode animated TV programme. The original illustrated book was in two colours which was appealing to parents. When it comes to television, in contrast to books, children decide what they watch. So the partners had to create a series that was instantly appealing to children. This included changing the palette of the book from black and white into full colour. In addition, the world of the main character had to be broadened, new friends and family had to be introduced. This is about creating and designing new ideas, images and narratives, including a brand, to be transmitted to the final user in the form of a television series and subsequently commercialised in other media and products. It is less about creating functional artefacts with a use value.

Knowledge inputs are of an aesthetic nature. Important inputs include the imagination of the individual artists and information about children's culture. The creative process relies strongly on an understanding of the habits of children and their everyday culture, including "what is hot". This information is obtained through intentional and unintentional observation and participation as well as through more intentional testing and market research. "It is almost like a requirement that they have Sky Kids at home […] just so that they are watching it, because you are nowhere without knowing what is current." (Interview Managing Director). These are all sources of inspiration for the individual artists. A formal research and development function is absent.

Dub Anim uses a range of sophisticated technologies and software applications, and its in-house R&D team even developed an animation tool specific to the project. However, innovative element does not lie in the technology. "We actually love technology here - it is very much what drives us. We really get a kick out of technology and new software new techniques. I would still say that it is our motto for us that our computers are akin to expensive pencils and they are only as good as the people operating them. So when you get an animator in here and you give him a

computer, that computer is only as good as the animator. It is probably the same piece of software that is probably used in *Lord of The Rings* as is used in some "cheap as chips" animation that is seen on *YouTube*. The difference is the person who is using it. While the technology is great and it is important to have it in place, it is also important not to let technology drive the creativity."

The activities rely strongly on tacit knowledge. This is partly related to the fact that each artist interprets everyday symbols differently. The knowledge about the book and its main character is embedded only in the cultures where the book was originally published. Know-how based on experience is clearly more important than know why and many animation activities have a strong craft character. "Animation is like a craft. You almost need to it, it is like carpentry." (Interview Managing Director) Although most artists would have enjoyed some form of animation related schooling, on-the-job training and experience are far more important and specialisation in one of the various skills occurs only after education. "We have a quite intense in-house training program. Some people come in working in commercials as runners, or just on scanning and copying DVDs, very menial tasks, and they build their own way up. So we have a lot of in-house training. Two of our editors began as scanners where they literally just took drawings and scanned them into machines - it's really the lowest rung. They've built their way up and they've found this position themselves. (Interview Director)

Dub Anim heavily depends on external partners for sharing production costs, accessing additional sources of finance, accessing cheap labour as well as for accessing complementary knowledge or skills (in this case mainly distribution knowledge and writing skills but in other cases this could involve musicians, voice over artists and so forth). The external actors differ from project to project. Know-who type knowledge and reputation are therefore paramount, particularly during the development stages.

In line with the synthetic knowledge base, the skills base is heterogeneous, both intra firm and inter-firm. Within Dub Anim, the production involves a range of actors that have developed specific skills including modellers, animators, lighting staff, editors, musicians, directors, producers, production managers and so forth. Some of the skills require a specific education. For example some of the sound engineers have an engineering background while some of the lighting people came from an architectural background with additional training in animation. However, many of the others would have enjoyed a rather general animation course and would have specialised in a particular role during their career.

Again in line with the synthetic knowledge base the animation trajectory is characterised by user-centred innovation and strong user-producer interaction. The broadcaster played an important role in the innovation process, commenting on the initial designs and providing ideas to make sure that the eventual design would be in line with the overall brand development process and would be suitable for the audience.

Although the symbolic knowledge base dominates during the first three stages its salience diminishes with each stage. Know-who type knowledge is really only important during the development stage. In addition, the production stage is a far less

creative stage. Although the activities of the Korean animation studio certainly include creative elements, “It is very prescribed, in that there is very little room for creativity or input from [the animators]. It is basically an exercise in joining the dots.” (Interview Executive Producer).

The salience of the symbolic knowledge base is further reduced with the transition to the post-production stage and it is no longer dominant. There is no room for artistic creativity. Arguably, the stage has as many characteristics of a synthetic as a symbolic knowledge base. Although it is still not about creating functional artefacts with a use value, the activities involve “synthesising” the various components (outcomes of the various activities) into an overall product. The activities have become more “mechanical” and totally process driven.

Table C1.1 summarizes the information regarding dominant knowledge bases and links this to the location of actors, the sources of knowledge and the salience of face-to-face contact between institutions

Table C1.1 Modes of knowledge creation, location of actors and intensity of face-to-face contact – computer animated children's TV series

	Dominant mode of knowledge creation	Location Actors	*Sources of knowledge (in order of importance)*	*Inter institutional face-to-face contact (frequency and number of people involved)*
1) Development	Symbolic	Production company USA; animation (focal) company Ireland; Channel USA	*For know who type knowledge:* Founding members and development team, based on visiting trade fairs and engagement in previous projects *For general ideas and inspiration:* Random sources including TV programs; DVDs Internet; trade journals; children playing; children's books; markets; computer games; primary school visits *For specific creative ideas*: As above, as well as client and partner	*For know who type knowledge:* Global: 3-5 times a year (trade fairs) Local: n.a. *Project related* Global: Multiple (about 4) contact moments involving small number of core commercial and artistic staff over period of 4 month. Some combined with trade fairs. Local (Ireland): n.a.
2) Pre-Production	Symbolic	Production company USA; animation (focal) company Ireland; Channel USA	*For general ideas and inspiration:* Random sources including TV programs; DVDs; Internet; trade journals; children playing; children's books; markets; computer games; primary school visits *For specific creative ideas*: As above, notably on-line research; as well as client and partner	Global: About once during the three month pre-production stage (director, art director). Local: n.a.
3) Production	Symbolic/Synthetic	Prod. Comp. USA; animation (focal) company Ireland; Channel USA; animation studio Korea	Embodied knowledge and internal staff	Global: About twice over the eight month production stage (director, art director). Local: n.a.
4) Post-Production	Synthetic/Symbolic	Animation (focal) company Ireland; Prod. Comp. USA; Channel USA; animation studio Korea	Embodied knowledge and internal staff	Global: About twice over the 3 month production stage (director, art director). Local: n.a.

C4.4 THE ORGANISATION OF KNOWLEDGE COMMUNITIES AND CENTRAL OCCUPATIONAL GROUP

C4.4.1 Occupational Groups

There are two main occupation groups within this case study: the creative team and the business team.

Within Dub Anim there are three teams (modelling, animation and lighting) but they are all from quite similar creative/design backgrounds and even the production manager and executive producer within Dub Anim have backgrounds in animation. The executive producer develops new projects but again shares the creative background of the core staff. Sub-contractors have very specific roles and skill sets and their inputs are mediated by the project manager. The company has few people in-house with business roles and a business training/background (two accountants and one payroll person).

The production team in South Korea also has a creative background but some issues emerged in translating the creative ideas into 3D animations. These would appear to relate more to cultural differences rather than to occupational differences.

Dub Anim has to deal with the 'business heads' in the brand management/marketing company CoDis and the cable broadcaster BroadChild. To some extent both CoDis and BroadChild act as intermediaries to the end user and provide the market and user knowledge to translate the creative idea into the final commodity. They work with the original creator of the IP to make sure that the vision of the creative work remains true to the original. The business and brand managers are very involved in the pre-production and post-production stages and play a role in determining the final creative content of the episodes as well as taking care of marketing and distribution.

C4.4.2 Heterarchical and Hierarchical Knowledge Flows

This case study and the core creative company interviewed is an example of a project based, networked and transnational production. In the pro-production stage of the project the company is focussed on developing creative designs in discussion with three external parties: the brand management company, the IP owner and the broadcaster. Later in production they work with a sub-contractor in South Korea and the brand manager and broadcaster. Moving on to post-production and sign-off again the network partners involve the creative company, the brand management company and the broadcaster. Of course the stages of production and post-production overlap, when one episode is in post-production the next one is in production, and thus the various partners are all involved over a relatively long period of time i.e. 2 years and this may be extended if the project secures continuation funding.

The core firm at the centre of this case is a medium sized company which is relatively uniform in occupational terms and non-hierarchical. However, given that this project is a contract/service project the final product and their role in the innovation process is negotiated and subject to the decisions made by two external partners, the broadcaster and the brand management company.

This project involves taking an existing creative work i.e. a book and turning it into a 3D animated television series. As such the focus is on animating an existing character and building upon and extending existing characters and stories. While within the creative company there is an attempt to be very open to all staff and encourage them to contribute ideas, these are then distilled by senior staff, and must then be presented and approved by the brand owner and broadcaster. As such the producers must negotiate between a range of opinions from creatives and business people involved in the pre-production stage.

Creative ideas within the Irish company come from a range of internal and external sources including previous experience, colleagues in the team, trade journals, websites, books, competitors (watching Sky kids and Nickelodeon programmes) and engaging with the end user group i.e. the appropriate age group of children. These resources are used for inspiration rather than 'solutions' or 'theories'. These ideas are then expressed using technical skills learned largely on the job. Most creative ideas are drawn on paper or using an electronic pencil so the core skills within the team are artistic ability and traditional drawing skills rather than technical proficiency. Staff hiring is largely on the basis of a 'show reel' of previous projects and reputation. 'Know how' and know who' are clearly important. Creative decisions are made largely on the basis of 'feeling right' and mediated through business/market knowledge of the end user market.

Outside of the company there is clearly a hierarchy with the brand owners and broadcaster occupying a position of power and the final decision on creative and business strategy. However the Irish company also negotiates the creative content with the South Korean contractor. There is little evidence in this project that this contractor has any creative input into the production process or that there is any symmetry of communication.

What is interesting in the interviews are discussions about the cultural specificity of expression of aspects of the creative content such as humour. When the designs are sent to South Korea for animation there have been disagreements about the style in which to animate things – which points to the tacit and cultural specificity of certain types of knowledge which would appear to be difficult to communicate in codified form and require much iteration. This is not an issue of 'local knowledge' but rather an issue of 'geo-cultural specificity' and understanding a particular 'Anglo-American approach to animation and humour'.

There is little to no engagement with academic institutions or academic research on graphics and animation.

The core creative company produces animated ads, television series and hopes to develop feature length films. The company describes animated ads as 'bread and butter' work which is fully commercial but not very high in prestige. Working on television series and feature length films is more prestigious while not necessarily economically rewarding unless the work can gain international recognition by being nominated for an international creative award.

C4.4.3 Organisation of Knowledge Communities

The key community for this Irish medium sized company is the international animation community involving both distributors (broadcasters, aggregators etc.) and other animation companies. Key to engaging with these two communities is attendance at international trade events, especially in North America and in France, supplemented by the online resources provided by these events.

In addition the internet is used to source labour, source creative ideas/do R&D, network with experts internationally and publicise the company. Individual members use and contribute to CGI Talk, an international on-line animation community. The company is also listed on Enterprise Ireland's animation website AnimationIreland. Much of this networking online is task and goal orientated.

While the company engages to a lesser extent with local companies this is clearly due to the stage of maturity of the firm as the director states that he used to attend every event going locally. Now that he knows the key players locally he just meets them at the international trade events.

Locally EI and the Irish Film Board are key resources in terms of funding travel to international events and providing seed capital to develop key projects, but appear to have little input to the substantive content and focus of the company.

The executive producer focuses on maintaining external links, developing new projects and pitching ideas to potential clients. They engage in weekly face to face meetings with producers of particular projects to make sure that they are meeting deadlines and track progress using an extensive project map drawn in excel.

Producers meanwhile have a more hands on and internal role in projects and engage in daily formal and informal meetings with the team in an open plan office. Contact and communications with the business managers in external companies involve face to face meetings during the contract negotiation and project set up phase but after that are more irregular and the project relies on tele-communications and virtual communications using e-mail, chat, VOIP and telephone. Differences within the team are negoatiated through face to face meetings and discussion while differences with the sub-contract team are communicated through their producer on the ground. Without recourse to scientific knowledge it would appear that the producer and executive producer draw upon their experience and knowledge of the user market to broker decisions while attempting to be inclusive.

C4.5 ORGANISATION OF FIRMS AND MARKETS

C4.5.1 The size of firms

Although the innovation trajectory of developing an animated television series is relatively short the investments are too sizeable for small animation companies to go it alone. Dub Anim's strategy is to be involved in international co-productions. In addition, the production company generally depends on large multinational distribution or broadcasting companies that have the necessary financial cloud to commission projects and provide advance payments.

Dub Anim employ 50 people directly, which is a medium sized company in the Irish context. The US broadcaster in this project operates 29 channels across Africa, Asia and the Pacific Rim, CIS/Baltic Republics, Europe, Latin America and the United States. As a sister company of MTV networks and a company of Viacom it is a major global player in the television and film industry active in production, publishing and distribution. Its home market is the US.

C4.5.2 The age profile of firms

CoDis the producer and BroadChild are relatively long established international companies. BroadChild has 25 years experience in children's television programming production, publishing and distribution. Dub Anim was established in 1993 and is an Irish company.

C4.5.3 Type of user markets

The commissioning client, the broadcaster, had a strong and direct role throughout the innovation trajectory. At the start it is involved in deciding on the main theme and feel of the series and throughout the innovation process it can directly determine the content via its comments on takes and retakes. "Often during production a note comes from the channel saying: oh no, you can't have the character in a boat without life jackets. Because we must comply with these kind of standards and practises, and so we have to find creative ways of being able to fix it" (Interview Director).

The eventual end-user, pre-school children, play a role as well. Passively children operate as a source for ideas and inspiration but children are also involved more actively during school visits when they are asked for their opinion regarding a particular book or video.

C4.6 INSTITUTIONAL CONTEXT

C4.6.1 Associational Networks

Although strongly networked in the international animation scene, Dub Anim is less strongly embedded in networks of formal and semi-formal associations. It does "help out" at a local third level institution. As a company, Dub Anim is a member of the Irish Business and Employers Confederation, the Irish Film and Television Awards (a platform to honour and celebrate Irish talent), the Screen Producers Ireland and Screen Training Ireland (a training initiative organised by the national employment agency). At least one of the staff is a member of professional associations. The creative director is involved in the Screen Directors Guild of Ireland. The Guild was established in 2000 as a representative body for Directors involved in the Irish and international audiovisual industry. Its goal is to support Irish screen directors and promote Irish directors on a national and international scale.

Enterprise Ireland, the national industrial promotion agency does manages the *AnimationIreland* web-site. The site functions as a promotion tool and knowledge repository for the Irish animation industry. However, companies do not need to be associated to be included on the site. Finally, individual members do use and contribute to *CGI Talk*, an international on-line animation community.

C4.6.2 Forms of regulation

To an extent the content of the series is indirectly regulated by the fact that the client broadcasters experience a level of government and self-regulation.

C4.6.3 Finance

The innovation trajectory of bringing a new animation series from concept to market is relatively short - about 16 months. Total investments amounted to $15m which was invested by CoDis, the multinational brand development company and main producer. Finance included an advance payment of the broadcaster. Dub Anim received $6m for the animation services. From Dub Anim's perspective this service type project is relatively low-risk. The down-side is that the company does not share in the back-end profits of the production.

In other projects Dub Anim acts as a co-producer. In those cases it is responsible for putting the finance package together. The company strongly benefits from Ireland's tax system, notably section 481 tax credits. This can provide a benefit of up to 28 per cent of eligible Irish expenditure. Still, Dub Anim rarely acts as a sole producer of a television series. The Irish market and the company are too small for raising the necessary finance. An international partner can reduce the production costs and provide complementary finance. In addition, having an international partner can provide access to international co-production treaty finance. In relation to this Dub Anim's strategy is to be involved in Canadian-Irish co-productions. This provides access to North American broadcasters as well as tax benefits under the Irish-Canadian Co-Production Treaty.

In 1993 the company was established as a very small enterprise without substantial start-up funding from state agencies

11 CASE STUDY 5

DEVELOPMENT AND PRODUCTION OF A 2D COMPUTER ANIMATED CHILDREN'S TELEVISION SERIES (KICKO)

C5.1 OVERVIEW

This case study concerns the development and production of a 2D, computer animated children's television series (52 episodes) targeting a primary school children's audience. The series is an original concept based around the antics of Kicko, a young animal that endeavours to learn martial arts. The innovation trajectory of a computer animated television series includes four stages: development, pre-production, production and post-production. Every episode involves a sequence of pre-production, production and post-production, although the amount of pre-production work gradually reduces. In addition, there is an element of overlap between the stages where problems in the post-production stages may require further production and even pre-production work.

The development stage is partly a creative (artistic) stage and partly about business development. Typically a production company will identify a theme based on an existing book or original idea and prepare a synopsis, often containing drawings to help visualise the key points. A key element of development is securing finance and attracting clients (pre-sales) for the series. Kicko is based on the original ideas of one of the founders of KilAnim, a small animation company located in Kilkenny, Ireland. In 2002, the company decided to bring the show into development with the co-founder acting as Executive Producer. The development stage focussed on finding new partners and securing the necessary finance. These activities were supported by artistic activities, mainly the development of a promotional trailer and first scripts. One of the distinguishing aspects of the show lay in the fact that it was developed using a commercial off the shelf animation programme called *Flash* but with comparable quality to higher end 3D animation programmes. Using Flash was relatively novel in the industry[9] at that time and usually reserved for animations for the internet as it allowed for the development of stripped down, memory light animations. It offered the potential of considerable savings in resources and time if sufficient quality could be achieved. The challenge was to apply the technology with limited loss of animation quality. The Director was able to develop the trailer practically on his own, including one of the first scripts with Flash.

After securing funds for initial development work from the Irish Film Board the show was successfully pitched at the 2003 Cartoon Forum, an international trade fair. This created the necessary interest from TV channels and potential partners. Over a three-year period the show turned into a co-production involving KilAnim, a Dutch production/distribution company (Coin Distribution), an Irish post-production house (TeleEire) and a large international children's programme broadcaster (BestBroadcasting). Although the show had been pre-sold to other TV channels worldwide, BestBroadcasting became a co-producer on the basis of being the largest

[9] But other companies had been doing it for some time.

investor. A US based, licensing and merchandising rights company (MerchUS) invested to exploit the licensing rights of the product.

In 2005 with the finance in place, the project moved in the pre-production stage. Pre-production starts with the very creative stage of further developing the basic rules of the show, referred to as "The Bible" in KilAnim. This included concept art work for characters and locations as well as developing ideas about what the show is about, the personality of the characters and so forth. Much of this work was done by KilAnim's Director in conjunction with US-based free-lance script writer/editors. This forms the basis for further, similarly artistic, pre-production activities involving (in 2D animation) script-writing, detailed character design, story board development and animatics[10].

At this stage, script writing was outsourced to a number of US based script-writers, co-ordinated by two script editors in New York. At the same time KilAnim recruited 35 people for its in-house pre-production and production team involving a range of skills including, amongst others, story boarders, background artists, animators, lay-out people, editors, a voice director, an art director, an animation director, an assistant director, a production manager and a producer. Most of the team were employed for the duration (18 month) of the project. The idea was to use Flash technology during the pre-production and production stages but KilAnim had no experience organising a production pipeline based on Flash. To solve this, the company approached a producer that had done similar work in a Canadian animation company (StudioQ). In addition, as a way of obtaining additional know how, a small amount of the pre-production activity was outsourced to the Canadian company as well. Some of the voice recordings took place at the studios of TeleEire in Galway.

With the pre-production for the first-episodes completed, the series goes into production. Production is a relatively less creative (read artistic) stage of realizing the pre-production work into an actual movie. "It's funny because [development is] very creative but once you're going into production it goes by as fast as a rocket. […] It's very difficult to have time to even think about it." (Interview executive producer). This work was contracted to two animation companies in the Philippines (MalDraw) and Malaysia. The activities were tightly organised and controlled by KilAnim, who employed a production supervisor to oversee the project on-site. The Philippines and Malaysian animators typically produced several versions of an episode, integrating editorial comments from KilAnim.

Post production, the final stage of creating a computer animated film involves editing the production work and creating the final episode by adding or perfecting additional effects such as sound effects, music and lighting. The editorial process involves several formal stages with the co-producers and main broadcaster clients providing their ideas and comments. Post-production activities were carried out at the studios of TeleEire, the Irish animation and film production company with a core expertise in post-production. They worked collaboratively with KilAnim's Director, Producer, Executive Producer and Voice Director. The first episode was aired in 2007 on CBBC in the UK. By the time of reporting the show had aired in 120 countries on major children's channels including Cartoon Network and Kids' WB in the US. In 2008, the

[10] An animatic or story reel is a full length storyboard synchronised with text sound and characters.

company received a number of accolades for Kicko, including the prestigious producer-of-the-year at the annual *Cartoon Forum* and best animation at the Irish Film and Television Awards.

We distinguish four different stages in the innovation trajectory.

1 Development.
2 Pre-production
3 Production
4 Post-production

C5.2 PATTERNS OF KNOWLEDGE FLOW AND INNOVATION

C5.2.1 Type of Actors and their Location

The original idea for the series was born during an informal brainstorming session during a Canadian film shoot involving one of the co-founders of KilAnim (and later Director of the series) and the company's sales representative. KilAnim is a young (1999), medium-size (70 employees when in production), yet award winning animation company established by a group of four animation students from Ballyfermot College for Further Education. The students founded the company when they were still in college, on the back of a final year project.

The actual artistic activities during this stage (development of initial ideas for the concept of the show and creation of the trailer) were largely done in-house. In fact, the use of Flash technology meant that the Director was able to develop the trailer practically on his own, including some of the initial scripts. Later in the development stage the company received input from external script writers. One, put forward by the Dutch co-producer, was based in France. At the end of the development phase the company employed the services of two US-based free-lance script writers/editors, previously employed by a major international children's television channel.

The three year development stage focussed on finding new partners and securing the necessary finance. The show was successfully pitched at the 2003 Cartoon Forum, an international trade fair, after which the show was bought by a large UK and a small Irish broadcaster. Following the event, KilAnim started partnering with Coin Distribution, a very small company in The Netherlands that acted as co-producer and distributor. The Dutch company did not contribute to the artistic work. It did not even have a studio. Nor did its location have any benefit in terms of finance or tax incentives. The main assets and value of the co-producer were its network and contacts with international distributors and broadcasters. The contacts of this company were instrumental in bringing in further clients, some of the script editors, the Canadian animation company, the producer as well as an additional co-producer, BestBroadcasting, a major international broadcasting channel mostly aimed at children, that invested large funds in the show. Although the show had been pre-sold to other TV channels worldwide, the large international broadcaster became a virtual co-producer on the basis of being the largest investor. A small US-based licensing and merchandising rights company (MerchUS) invested to exploit the licensing rights of the product. Finally, a small (50 employees) animation and film production company (TeleEire) invested in the show and was to take care of some of the post-production

and, to a lesser extent, pre-production work. One of the reasons for selecting TeleEire was because it provided further opportunities to exploit Ireland's section 481 tax incentives.

Throughout the remainder of the innovation trajectory the role of the Dutch co-producer remained focussed on distribution and sales. It had little input in the creative (artistic) aspects of the show. The role of the initial client (international broadcaster) and broadcaster/co-producer involved commenting on work at different stages in the development of episodes to ensure that the product is suitable for its target audience. TeleEire only started to have a significant input during the post-production stage.

The same players are involved in the pre-production stage. KilAnim takes responsibility for most of the creative (artistic) work. The two US-based script writers are retained and get the responsibility for script editing. The actual script writing was outsourced to a number of US based script-writers, co-ordinated by the two script editors. The voice recordings took place at the studios of TeleEire in Galway. A small amount of the pre-production activity (lay-out and character posing was outsourced to StudioQ, a Canadian company and former employer of KilAnim's new producer. This deal provided KilAnim with some security and confidence in the form of expertise. StudioQ had been using Flash technology for animating series for years and had a pipeline relationship with an animation studio (production stage) in the Far East. Although helpful at the time, in future projects of this kind, KilAnim intends to keep all pre-production activities in-house.

Internally, KilAnim put together a pre-production and production team of about 35 people with a range of skills including amongst others, story boarders, background artists, animators, lay-out people, editors, a Voice Director, an Art Director, an Animation Director, an Assistant Director a Production Manager and a Producer. The creative activities are directed by the Director and Assistant Director with input from the Art Director and Voice Director. The Producer co-ordinates and supervises the various activities, both internally and externally, and is responsible for hiring key personnel. Most of the staff is recruited, and will remain in place, for the duration of the project. The Canadian producer was recruited because of his experience with organising a production pipeline based on Flash in other companies (including StudioQ). Similarly, other core staff, such as the assistant director, was recruited partly on the basis of their experience of Flash animation. The crew was truly international, mostly recruited from Europe. Positions for which no suitable candidates could be found were filled with Canadians that the new producer had worked with.

In the production stage, the relatively less creative (read artistic) activity of realising the pre-production templates for individual episodes was initially outsourced to a animation company in the Philippines (MalDraw) with whom StudioQ had an existing pipeline relationship. The activities are tightly organised and controlled by KilAnim, who employed a production supervisor (rather than an artistic one) to oversee the project on-site. During the production stage, with the project in danger of falling behind, the producer decided to contract a second animation company in Malaysia.

Finally, most of the post-production activities were carried out at the studios of co-producer TeleEire, a small Irish animation and film production company with a core

expertise in post-production, located in Galway (a 2-hour drive from Kilkenny). The company worked collaboratively with KilAnim's Director, Producer, Executive Producer and Voice Director. The initial client (international broadcaster) and broadcaster/co-producer are involved by commenting on different versions of the episodes.

C5.2.2 Sources of Knowledge

The original idea for the series was born during an informal brainstorming session during a Canadian film shoot involving one of the co-founders of KilAnim (and later Director of the series) and the company's sales representative. Both of them liked martial arts films and started thinking about how they could translate this into a children's animation series. They linked the colours of the related Yin Yang symbol to the animal world and the concept was born. The Director discussed the idea with the Managing Director and they decided to bring it into development. The development of the first trailer was done largely in-house. The use of Flash technology meant that the Director was able to develop the trailer practically on his own, including the initial scripts. The sources of ideas are mainly the imagination and embodied knowledge of the Director. Further inspiration was obtained by watching martial arts movies while colleagues would provide regular feedback. Later during the development stage external script writers become an additional source of ideas.

Know how related to the use of Flash technology was based on previous experience. Initially, one of the company's bread-and-butter activities involved designing flash cards for internet sites. The software was bought off the shelf and the know how of using it for animation purposes was developed on the job. "When flash came out people started to animate on the internet using flash - people did it naturally. We weren't working with it in college or anything like that. It was just a program we got and that we continued to use. We realised, 'oh right, you can animate with this.' So we kept experimenting with it. […] It was really just practice. Because we had done an advert for [a client] and we had all been doing a lot of similar work. So we all discovered our own kind of methodology of working through it." (Interview Executive Producer).

Know who type of knowledge is particularly important during the development phase for finding partners. Some of this knowledge was embodied in the founders of the company based on previous projects and regular attendance at annual international trade fairs/festivals (e.g. MIPCOM, MIP Junior; KidScreen, MIFA). However, the company was still relatively young and the company did not have all the necessary contacts. The main source of know who type knowledge was the Dutch co-producer/distributor. The contacts of this company were instrumental in bringing in further clients, some of the script editors (with whom he had worked before), the Canadian animation company as well as an additional co-producer, BestBroadcasting, a major international broadcasting company that invested large funds in the show (see section on finding partners). The two script editors/writers contributed important know who type knowledge regarding the writers. Know who type knowledge appears to involve an element of snowballing with new partners contributing additional know who type knowledge to the project. (The newly recruited producer and StudioQ play a similar role in relation to the production studios. See below.)

During the pre-production stage the artists again rely to a large extent on their embodied knowledge and artistic imagination and the directions of the Director. In addition martial arts films remain a crucial source of information for all. As the basic rules of the show (referred to as the "The Bible" in KilAnim) become increasingly solid and the library of characters expands, these become an increasingly important source for individual animation artists and writers alike. "The inspiration comes down to somebody sitting down and just thinking trying to think about a story but based on the material. It involves thinking of the characters and then based on locations they might have seen in The Bible, like sample locations and artwork and so on. This eventually spawns an idea. But also we encourage all the writers and all the story boarders and all the crew here to watch a lot of old Chinese Kung Fu films. We have loads of old Kung Fu films." (Interview executive producer). The writers relied on their own creative imagination, "the Bible" and an initial brainstorming session attended by all writers.

The series targets six-to-twelve-years old school children. Surprisingly, KilAnim appears to have little in-house knowledge about the preferences of the age group and current children's culture and the company spend no resources on collecting it. When asked about the importance of being in contact with the age group the executive producer states: "Well I don't know. I think we were making the cartoon based on something that we liked. None of us actually had kids of our own. Maybe it is easier if you have a six-to-twelve year old kid. You can understand a bit better, […] whereas we were remembering shows that we liked as kids." Most of this type of knowledge came from the script editors and the broadcasters. The broadcasters knew their audiences well and through their commentary on scripts and various takes they influenced the content of the show. Some of the comments focussed on the "correctness" of the content for their audience but they would also contribute positive ideas as to what would be funny to include in the show.

Recruitment was an important way of gaining knowledge during the pre-production stage and even the production stage. The assistant director was recruited partly on the basis of his experience of Flash animation. The Canadian producer was recruited because of his experience with organising a production pipeline based on Flash in other companies. The producer was also an important source of know who knowledge which was of value for recruiting further crew and for identifying suitable animation studios during the production stage. To an extent, StudioQ, the Canadian animation company, brought similar knowledge. Although, in hindsight, the Canadian studio's contribution lay more in providing a sense of security and confidence than in actually contributing knowledge. Recruitment to the Irish production team was on the basis of their artistic skills and experience rather than their qualifications. Finally, the Galway animation company was an important source of know how during the post-production stage.

C5.2.3 Finding Partners

Given their experience in other projects the company was reasonably informed about potential clients for the show but did not have all the necessary contacts. At the start of the development phase KilAnim approached a number of potential clients either during one of the annual international trade fairs/festivals (e.g. MIPCOM, MIP Junior; KidScreen, MIFA) or during a company visit. Some pre-sales were made on this basis. The big breakthrough came after the successful pitch at Cartoon Forum, an

international trade show. A number of potential partners approached KilAnim, including the small Dutch production and distribution company. The main assets and value of the co-producer were his know-who type knowledge - its network and contacts with international distributors and broadcasters. The contacts of this company were instrumental in bringing in further clients, some of the script editors (with whom he had worked before), the Canadian animation company as well as an additional co-producer, BestBroadcasting, the major international children's channel that invested large funds in the show. The small Irish post-production house (TeleEire) was selected partly on the basis that it provided further opportunities to exploit Ireland's section 481 tax incentives. The Irish animation scene is very small and the company was known to KilAnim.

The script editors, in turn, knew all the US writers that were working on the show. The external production companies (in Canada, The Philippines and Malaysia were identified and contacted on the back of the experience of the newly recruited producer. He had previously worked at the Canadian company where he had co-ordinated a pipeline involving the Philippines company. Finding partners is also supported by word-of-mouth and the international trade fairs "It is a very small industry. We know the studios. Definitely, producers talk." (Interview Producer)

KilAnim used multiple channels to identify and select project crew. The Irish pool is limited. As a result the crew is very international, mostly recruited from Europe and some from Canada. Some of these people heard about vacancies on-line, by reading KilAnim's ads on animation specific international recruitment sites or forums such as *Animation World Network*. The company's website and the show's dedicated blog were an important source of recruitment as well. A small number of staff was recruited via the unemployment office. The company did not use recruitment agencies. More specialised or crucial positions were filled partly on the basis of word-of-mouth or the producer's personal experience of working with individuals. Student internships are another source of recruitment. The company has a regular flow of student interns from colleges all over Europe, including Ireland, France and Denmark.

C5.2.4 Mode of Knowledge Exchange, Proximity and Level of Intentionality

The main actors during the development stage were KilAnim (the lead producer), Coin Distribution (the distributor/co-producer in the Netherlands), BestBroadcasting (the international broadcaster), TeleEire (the co-producer in Galway) and external script writers in France and US. Most of the artistic development work was done by the Director at KilAnim with some input from the freelance script writers, while most of the development work, certainly after the initial phase, was done by the Dutch co-producer/distributor.

Since most of the creative (artistic) development was conducted in-house, this involved relatively limited communication with external partners. The Director received a number of scripts from external script writers but this required little communication and no face-to-face meetings. Sales and business development issues, on the other hand, involve a lot of communication. Initially KilAnim communicated with several broadcasters and distributors but with the entry of Coin Distribution most of this communication was handled by the new partner.

Initially KilAnim established first contact with potential partners and clients during face-to-face meetings at one of the international trade fairs/festivals (e.g. MIPCOM, MIP Junior; KidScreen, MIFA) or during a company visit. These can be substantial meetings: "We had a meeting with about ten of them at MIPCOM. They were all people from [the distributor], giving us advice and outlining what they were going to do, and so on." (Interview executive producer). Subsequent contact was maintained via phone and email. With the entry of Coin Distribution most of this work was done by the new partner but KilAnim now had intensive communication with the Dutch Distributor. This involved a substantial amount of face-to-face contact between the development team at KilAnim and one individual at the Distributor. "We met constantly, […] he was here quite often." (Interview executive producer). Sales related communication would continue during the subsequent phases of the innovation trajectory to support additional sales.

Partner choice appears relatively insensitive to distance decay. Both the Dutch distributor co-producer and the main broadcaster/co-producer have their offices overseas. The partners were selected on the basis of know who and finance they could contribute to the project. KilAnim was relatively well informed about the relevant international players, partly due to experience in previous projects and by visiting trade fairs and conferences. The development stage involves a substantial amount of face-to-face contact moments but these can be efficiently organised though frequent short-term visits, some of which are combined with trade fairs. Later in the development stage, most of the deal making is co-ordinated by a single person at the Dutch distributor who does most of the travelling.

The selection of the Galway co-producer is partly driven by distance (although on the scale of Ireland it is located far from KilAnim) and co-ordination issues (see below) and partly because it provided further opportunities to exploit Ireland's tax and financial incentives[11]. Interestingly, in other projects of KilAnim, tax consideration actually lead to the selection of overseas partners, notably in France. Partners operating in small markets are unable to raise sufficient finance in their own market. One of the reasons to work with co-producers abroad is that this will provide the necessary complementary finance.

The pre-production, production and post production stages involve a great amount of communication between the various actors, which now include the animation studios in Canada and the Far East. Most of the communication now focuses on artistic and production co-ordination issues. The pre-production stage involves intensive communication between the Director and the US script editors. All of this communication is conducted by email and telephone. The communication with the actual script writers is mediated by the two US editors. The initial communication of the concepts and ideas of the show (to the writers) involves a strong tacit component and is organised through a large writers meeting. After this all communication is handled by phone and email. The voice recordings were done at the studios of the Galway co-producer involving staff from the co-producer and KilAnim (see below)

[11] The company is located in The Gaeltacht region of Ireland which secured further (regional development related) funding

The communication with the Canadian animation studio as well as the Philippines and Malaysian studios again involves a large amount of communication. The project pipeline involves the development of characters, backgrounds, layouts and multiple takes and retakes. All this material with notes and comments is going back and forth all these actors. Most of the material, including notes is transferred electronically using FTP (see below) but the process does involve a substantial amount of email and phone communication. The pre-production related communication with StudioQ in Canada involved a tacit component, but involved little face-to-face contact. This is probably related to the fact that StudioQ only took care of a small amount (5%) of the pre-production work.

The animation work of the Malaysian and Philippines studio is far more prescribed and the knowledge input (from KilAnim) is far more codified[12]. It is easier to communicate the information involved. KilAnim employed an overseas supervisor to oversee the project on the ground. However he was employed to oversee the production schedules rather than the artistic content. At this stage strong co-ordination is required to stay within the scheduled delivery deadlines of the project. No overseas supervisor was employed in the second (Malaysian) studio. Other face-to-face contact between KilAnim and the three overseas studios was limited to "meet and greet" meetings and very sporadic project meetings. "I think [face-to-face contact] is very important, even just to "meet and greet". You need to forge relationships. Then it is not just an anonymous guy on the other end giving you retakes. I think that is important. Other than that, it is also useful to meet just to "catch up". You need to have production meetings if there are problems and even if there are not. You have meetings with your subcontractor just to tell them that they are doing a great job." (Interview producer). Some of these "catching up" meetings take place during the international trade fairs

The choice of the overseas studios is insensitive to distance decay. The partners were selected on the basis of the knowledge/skills they could contribute to the project (StudioQ) as well as competence and price competitiveness (the studios in the Far East). They were identified by the Dutch co-producer and internal producer on the basis of embodied know who type knowledge. These people were well informed about the relevant international players mainly due to experience in previous projects and by visiting trade fairs and conferences. In one case co-ordination was deemed to require face-to-face contact. But this was efficiently organised through temporary proximity in the form of an overseas supervisor.

Most of the post-production activities were carried out at the studio of co-producer TeleEire. This was a truly collaborative effort with the Director and Voice Director of KilAnim working shoulder-to-shoulder with the engineers from TeleEire, directing the voice artists, integrating sound effects, and so forth. Toward the end of the innovation trajectory this happened every second week. The choice of the post-production partner appears to be partly driven by geographical location (and partly due to finance). The requirements for shoulder-to-shoulder work are so great that companies generally prefer to conduct these activities in-house.

[12] This is not to say that there was absolutely no communication regarding artistic issues.

Within KilAnim, although most individuals or teams have specific skills, the various stages involve a substantial amount of near shoulder-to-shoulder work and a great amount of communication, including face-to-face. Most of the activities are conducted in an open office environment. The project involves regular co-ordination meetings. In addition, core staff such as the Director, supporting Directors and Producer would regularly walk the floor to look over shoulders, answer questions and give opinions.

Although most knowledge flow is intentional, there is evidence of unintentional knowledge flow, notably "know who" type knowledge. The international trade fairs (e.g. MIPCOM, MIP Junior; KidScreen, MIFA) play an important role in this. One of the main functions of such events is to meet new potential partners and to keep informed about the relevant actors in the industry. Although the actors attend these events with the specific intention to gather such knowledge, a substantial amount of knowledge and information exchange is at least unplanned or unforeseen. Further (partially) unintentional information exchange of know who type knowledge is mediated by internet forums.

The interviews provided little information regarding inspiration type knowledge but some of this is obtained unintentionally as well. Although most artists had no children of their own they appear to have at least some knowledge of children's culture which proved important for the attraction of the show. "We just did the show the way we wanted to do it and as it turned out we were sort of noticing things like … oh, the colour path we have here is nice and girls would like that, and the black and white action sequences work very well". […] Boys love black - black and red seems to be their colour co-ordination. If you see their clothes, it is usually black and whites and reds. That is what boys seem to gravitate towards and girls are more pastel and so we had a very pastel colour scheme for the background." (Interview executive producer)

Interestingly this unintentional knowledge exchange through "buzz" mainly operates at an international or virtual level. Local buzz appears to be of limited relevance for knowledge flow. All the trade fairs that are attended are international events. The potential local places of know-who-related buzz are limited to the Screen Directors Guild, the Enterprise Ireland Animation CEO Forum and the annual IFTA wards. In addition, individual staff members do meet members of the animation community socially, for example during rap parties organised by the various companies. Finally, Enterprise Ireland, the national industrial promotion agency does manage the *AnimationIreland* web-site. It is possible that the buzz generated during these events includes know who type knowledge but its relevance for this project, relative to the international events, is limited. "The [Irish] community is so small and we all go to the same events. I meet them quite regularly at the markets" (Interview executive producer). The producer of KilAnim had been approached by members of the Guild and had provided some know how about organising production pipelines involving Flash technology. Although the actual know how exchange was intentional, the initial approach (know who) may have been facilitated by buzz.

KilAnim uses a number of digital environments for external knowledge exchange. Email is used extensively as a communication tool. The Internet is used to communicate the project to the outside world (project-specific blog) and for

recruitment purposes. In relation to this KilAnim advertises its vacancies on its own website as well as on animation specific international recruitment sites or forums such as *Animation World Network*. The digital transfer of data between the partners is mediated through an FTP site, and co-ordinated by a staff member of KilAnim. The company had briefly tried out a proprietary web-based project management system (Hobsoft) which allowed partners in different locations to log on and get access to relevant and up-to-date project material. However, the producer did not use the system because it did not satisfy all his co-ordination requirements and because the bandwidth capacity in Kilkenny was insufficient for hosting the server for the global network.

C5.2.5 Importance of the Region / Ireland

The company was founded by friends who were all final year students from Ballyfermot College for Further Education in Dublin. The location in Kilkenny is partly related to the fact that two of the founders grew up in this small town. There was also a push factor involved. “Really, the decision to come down [to Kilkenny] was because we were tired of Dublin.” (Interview, executive producer)

Apart from the tax incentives (see below), the company derives few specific benefits from its location in Kilkenny or Ireland. In relation to the specific series under discussion, one of the co-producers is located in Ireland (which is partly driven by the fact that the company is located in *The Gaeltacht* region of Ireland which brings additional tax and financial incentives to the projects). However, the most significant co-producers in terms of know who and finance and all other contractors are located oversees as well (Canada, USA, Philippines, Malaysia). Finally the main markets are international. Apart from their small size, historically the Irish broadcasters have been particularly poor with commissioning animation productions.

The main sources of knowledge (know who, know how and inspiration) are embodied in the firm, international (e.g. trade fairs and festivals) or virtual (DVDs, International on-line Forums). The Irish animation community may contribute some know who type knowledge but this is insignificant compared to the international element.

The regional animation cluster is small by international standards and the sectoral system of innovation is only starting to develop. The legacy of classical animation companies such as Sullivan Bluth, and the development of the third-level training and education infrastructure in the form of the Ballyfermot College and the Dun Laoghaire Institute of Art Design and Technology do provide an important source of skilled labour, but the skills base remains limited. The company had to rely extensively on international recruiting and the crew is very international, mostly recruited from Europe and Canada. Recruitment was further complicated by the location in the small town of Kilkenny, at a distance from Dublin, Ireland’s main concentration of media companies and skilled workers. This made it more difficult to attract short-term (couple of days to weeks) crew.

Again, the important business networks are global in nature and the networking events are primarily international events. Although, increased since the 2000s, the potential local places of know-who-related buzz remain limited to the Screen Directors Guild, the Enterprise Ireland Animation CEO Forum and the annual IFTA wards. In addition, individual staff members do meet members of the animation community

socially, for example during rap parties organised by the various companies. It is possible that the buzz generated during these events includes know who type knowledge but its relevance, relative to the international events, is limited. “The [Irish] community is so small and we all go to the same events. I meet them quite regularly at the markets” (Interview executive producer).

The location in Ireland is beneficial primarily because of the available fiscal and financial incentives. Without the development loan from the Irish Film Board the start-up company series would have been unable to develop the series. The company also strongly benefits from Ireland’s tax system, notably section 481 tax credits. This can provide a benefit of up to 28 per cent of eligible Irish expenditure. In addition, Enterprise Ireland, the national industrial promotion agency provides support for companies to visit international conferences. This agency also manages the *AnimationIreland* web-site. The site functions as a promotion tool and knowledge repository for the Irish animation industry.

C5.3 TYPE OF KNOWLEDGE CREATION

The first three stages are dominated by a symbolic mode of knowledge creation although its level of dominance diminished with each stage. The creative innovation of the project lies mainly in the concept of the story/characters, the quality of the animation and the scripts for the various episodes. The concept of the story and the main characters is about creating and designing new ideas, images and narratives, including a brand, to be transmitted to the final user in the form of a television series and subsequently commercialised in other media and products. It is less about creating functional artefacts with a use value.

Knowledge inputs are of an aesthetic nature and demand ability in symbol interpretation. Important inputs include the imagination of the individual artists and existing symbols and images. During the initial brainstorming session of the show the concept started with the name for the show “and both of [the participants] like Kung Fu so they tried to think […] what is like Kung Fu and sort of Zen. Then they thought of the Ying Yang symbol and they thought about what else is black and white…” (Interview executive producer). All artists are encouraged to watch Kung Fu films. In addition, the success of the creation depends, at least to some extent, on an understanding of children’s habits and everyday culture. “We just did the show the way we wanted to do it and as it turned out we were sort of noticing things like … oh, the colour path we have here is nice and girls would like that, and the black and white action sequences work very well. […] Boys love black - black and red seems to be their colour co-ordination. If you see their clothes, it is usually black and whites and reds. That is what boys seem to gravitate towards and girls are more pastel and so we had a very pastel colour scheme for the background.” (Interview executive producer). A formal research and development function is absent.

One of the distinguishing aspects of the show lay in the use of Flash technology. However, this is not why the show received its award. The company did not develop new software. The Flash software was a generic software product and other companies, notably in Canada had used it to create animated movies before and had developed a related pipeline co-ordination system. The Director at KilAnim had used

it to create quality animation. The company came up with painterly effects, making it look like traditional paper animation. “We really pushed it and pushed the software.” (Interview executive producer) The use of Flash seriously reduced the production costs and resources. This enabled the company to maintain a high quality throughout the series which was one of the reasons why the series had won the awards.

The activities, notably during the early stages, rely strongly on tacit knowledge. Know-how based on experience is clearly more important than know why and many animation activities have a strong craft character. Most artists had enjoyed some form of animation related schooling, typically vocational education or the international equivalent, but on-the-job training and experience are very important. For example know how related to Flash technology was based on previous experience. Initially, one of the company’s bread-and-butter activities involved designing flash cards for internet sites. The software was bought of the shelf and the know how of using it for animation purposes was developed on the job. “When flash came out people started to animate on the internet using flash - people did it naturally. We weren’t working with it in college or anything like that. It was just a program we got and that we continued to use. We realised, ‘oh right, you can animate with this.’ So we kept experimenting with it. […] It was really just practice. Because we had done an advert for [a client] and we had all been doing a lot of similar work. So we all discovered our own kind of methodology of working through it.” (Interview Executive Producer)

Specialisation in one of the various skills occurs generally after education. The college courses tend to teach all aspects of animation, including drawing, design animation, production and artists tend to specialise in an area they show most aptitude for or have most affinity with.

KilAnim depends on external partners for sharing production costs, accessing additional sources of finance, accessing cheap labour as well as for accessing complementary knowledge or skills. The Dutch co-producer, US licensing partner and the co-producer/broadcaster all contribute very different competences while the three main animation companies all contribute expertise in specific areas. The external actors differ from project to project. Know-who type knowledge and reputation are therefore paramount, particularly during the development stages.

In line with the synthetic knowledge base, the skills base is heterogeneous, both intra firm and inter-firm. Within KilAnim the production involves a range of actors that have developed specific skills including designers, animators, lighting staff, editors, directors, producers, production managers and so forth. Some of the skills require a specific education. However, most artists would have enjoyed a rather general animation course and would have specialised in a particular role during their career.

Again in line with the synthetic knowledge base the animation trajectory is characterised by user-centred innovation and strong user-producer interaction. The broadcaster played an important role in the innovation process, commenting on the initial designs and providing ideas to make sure that the eventual design would be in line with the overall brand development process and would be suitable for the audience.

Although the symbolic knowledge base dominates during the first three stages its salience diminishes with each stage. Know-who type knowledge is most important during the development stage (although the distributor continues the sales function throughout the trajectory). In addition, the production stage is a far less creative (read artistic) stage. “It’s funny because [development is] very creative but once you’re going into production it goes by as fast as a rocket. […] It’s very difficult to have time to even think about it.” [The animation studios in the Far East] are doing a lot of animation but if its already posed you already have the facial expressions. […] some of the storyboards are very detailed. They are literally just looking at the storyboard that is drawn in black and white and putting the model character on top of that pose. So they are doing the same general pose.” (Interview executive producer).

The salience of the symbolic knowledge base is further reduced with the transition to the post-production stage and it is no longer dominant (at least as far as the focal company is concerned). There is little room for artistic creativity. Arguably, the stage has as many characteristics of a synthetic as a symbolic knowledge base. Although it is still not about creating functional artefacts with a use value, the activities involve mixing or “synthesising” the various components (outcomes of the various activities) into an overall product. The activities have become more “mechanical” and process driven.

Table C5.1 summarizes the information regarding dominant knowledge bases and links this to the location of actors, the sources of knowledge and the salience of face-to-face contact between institutions.

Table C5.1: Modes of knowledge creation, location of actors and intensity of face-to-face contact – 2D animated TV series (Kicko)

	Dominant mode of knowledge creation	Location Actors	*Sources of knowledge (in order of importance)*	*Inter institutional face-to-face contact (frequency and number of people involved)*
1) Development	Symbolic	Production company Ireland; Co-producer/ distributor The Netherlands; Broadcaster/Co-producer Germany and UK; Co-producer animation Ireland	*For know who type knowledge:* Co-producer distributor; Founding members, based on visiting trade fairs and engagement in previous projects *For general ideas and inspiration:* Kung Fu films, as well as general observation of children *For specific creative ideas*: Kung Fu films, script writers and commissioning client *For know how type knowledge* Embodied knowledge and based on previous experience with software	*For know who type knowledge* Global: multiple times a year (trade fairs) Local: n.a. *For project content and co-ordination* Global: very frequent with distributor/co-producer; none with script writers Local (Ireland): once for meet and greet.
2) Pre-Production	Symbolic	Production company Ireland; Animation contractor Canada; Co-producer animation Ireland;	As above but Canadian contractor and Irish co-producer becomes an additional source of know how; Recruitment provides important know how type knowledge Know who knowledge (recruitment): newly recruited producer; embodied knowledge founders;	Global: once for meet and greet (executive producer and producer). Local: several recording sessions at co-producer's studio.
3) Production	Symbolic/Synthetic	Production company Ireland; Animation contractors Philippines and Malaysia; Co-producer animation Ireland; Animation contractor Canada;	Embodied knowledge and internal staff	Global: once for meet and greet and once for co-ordination problem solving over the production stage (producer only). Local: none.
4) Post-Production	Synthetic/Symbolic	Production company Ireland; Co-Producer Ireland	Embodied knowledge and internal staff; Irish co-producer adds know how type knowledge	Global: none Local: every second week over the post-production period (three directors)

C5.4 THE ORGANISATION OF KNOWLEDGE COMMUNITIES AND CENTRAL OCCUPATIONAL GROUP

C5.4.1 Occupational Groups

The dominant occupational group within the firm is that of 'animators'. However, this broad heading encompasses a variety of different roles. The main (in terms of numbers) activities/skills are:

* Design animators[13] and modellers (modellers for 3D animation only). These are responsible for the look and feel of the show (during the development and pre-production phase)
* Background artist (responsible for designing the backgrounds) (during the development and pre-production phase)
*Story boarders (responsible for developing a long comic of an entire episode). This is done by animators as well, but the design element of the activity is already reduced (this is part of the pre-production stage)
*Layout
*Production stage animation. This is part of the production stage and is done by animators. Compared to design animation this is the less creative activity of populating the template. If a company does the actual production in house, they require a large group of animators. However, this was not the case in KilAnim as this work was outsourced.

On top of these activities you have a range of other activities conducted by other specialized staff. At the pre-production stage you have voice engineers (technical staff that are responsible for recording the voices of artists); at the end of the trajectory you need a sound engineer, a person that puts the animatics together (full length story board with text voice and characters), and a lighting person. Furthermore, a number of editors are required for editing the various takes and retakes at various stages.

Finally, all these people need to be directed and coordinated. Apart from the director who received inputs from a range of specialized directors (art director; animation director, an assistant director; sometimes a light director) this requires a producer and a production manager. Some of these are specialized in one of the skills mentioned above.

Most of these diverse roles (with the exception of the more specific technical specialisations) fall within the occupation of 'animation', even though careers will develop into different combinations of these different roles and individuals will specialise over time in particular activities. Furthermore, some people will take various roles during the project, further blurring any clear divisions between these roles or their formation into distinct occupations.

Elsewhere in the production network, there are other occupations. The interaction with the broadcast sector is particularly important in this regard. However, the

[13] Although, as a function, design is usually separated from (production) animation, it is conducted by people with an animation background

different occupations in the broadcasters involved in this production network have little direct effect on the innovation process. Discussions with the broadcasters take place through a small number of individuals who interact with senior producers from KilAnim. Nonetheless, the broadcaster's knowledge of children's media use is an important element in the development of the animation, even if indirect. The occupational basis of this work is unclear.

C5.4.2 Heterarchical and Hierarchical Knowledge Flows

There is a dispersed network of actors involved in production and innovation, spread across KilAnim, the broadcaster, script writers, and a variety of external partners.

There are two main integrating mechanisms for this knowledge within KilAnim. The first is the strong authority of a single creative individual who exercises tight oversight, with relatively little delegation (and who tends to be over-worked). In that respect, KilAnim is 'creative-driven' to an extent that goes beyond the strong concentration of creative work in a small core group in the other media firms we analysed.

The second mechanism is the strong shared occupational culture around 'animation' that includes designers, storyboarders and animators. As noted above, despite the diverse roles and implicit hierarchies among those roles, the shared background and identity of 'animator' creates a strong collective identity within the firm – and, perhaps more importantly, the project (as may of those working on the project are only temporary members of the firm).

These mechanisms tend to minimise heterarchical interactions, in the sense of interactions across disciplinary or professional boundaries. This is partly because animation as a profession has a wide range, relatively little internal specialisation and relatively loose boundaries, thus being a 'heterarchical' profession to begin with.

However, there is also relatively little development of an organisational hierarchy as the personal authority of the central figure is more important here than in other firms.

However, these integrating/ controlling forces are not without their difficulties. Internally, some of the animation community of practice have been dissatisfied with the authority of the central figure and one, at least, has left because of it. Ironically, the network structure may facilitate this centralisation of decision making authority in this case.

The contract status and relatively temporary involvement of many of the other 'creatives' changes power relations within the firm, favouring permanent senior staff; writers pitch for shows and the lead producer decides which is to be developed; animators are in the Philippines with little creative input; the co-producer deals with networks and leaves inspiration and imagination to the lead, and so on.

C5.4.3 Organisation of Knowledge Communities

The core ideas for the KilAnim project rest with an individual and a small surrounding group. The primary challenge in terms of the organisation of knowledge communities is the scaling up and networking out of this core group, through

involving external scriptwriters, broadcast, routine animators, and others in the production process.
There are a variety of modes of extension through these networks. Personal ties are crucial with pre-existing personal networks (know-who) vital to generating knowledge about developments and potential partners. Recruitment of new staff is an ongoing process, given the temporary status of most staff and the hiring of new staff for new projects. The project history of key staff and attendance at trade fairs were sources of knowledge about the international players. A co-producer was brought in who worked the networks. International ties were driven in large part by the search for finance and the need for market expansion

International ties are the key networks, while local networks are not crucial to the business. However, the creative core itself is embedded in a social community of shared interests – eg in martial arts (where senior producers had staff watching *Kung Fu* movies). There are loose local connections, which is almost all peer-to-peer, concentrated among developers/ animators and is almost all informal, although facilitated by awards, websites etc. The company, editors, also creates it own 'local spaces' occasionally to facilitate intensive discussion e.g. setting up writers' meetings (organised by the free-lance script editors).

While they did not surface on this project there have been organisational difficulties around the management of the production process – particularly though conflicts between French and US contractors related to management style. Arguably, this may be because national differences matter more here where they are less easily smoothed over by the shared cultural world of the developers/ animators. The animators culture is relatively homogenous across the Anglo-American world – both technically and culturally (one of the companies in an other case study also mentioned difficulties with Korean contractors in interpreting US-style humour. In Ireland the orientation to the US is reinforced by small domestic markets and a US-centric culture, and further reinforced by the search for partners who bring in additional finance.

C5.5 ORGANISATION OF FIRMS AND MARKETS

C5.5.1 The size of firms

Although the innovation trajectory of developing a full length animated television series is relatively short the investments are too sizeable for small animation companies to go it alone. Even the relatively small amount of finance required for the initial stages of the development stage may be too great for small animation companies like KilAnim. In this regard, the funding from the Irish Film Board was crucial. After this the company necessarily relies on the co-production format. This generally includes one large foreign distribution or broadcasting company with the required financial clout to commission projects or provide advance payments.

C5.5.2 The age profile of firms

At the start of the innovation trajectory, KilAnim was only three years established as a company. The Dutch co-producer had started as a one-person operation and merged with a small distribution focussed company during the development phase. The Irish co-producer TeleEire and the Canadian animation studio were both established at the end of the 1980s and had been involved in several successful projects. The

International children's channel/co-producer was only launched in 1995 but was established as a joint venture between two long established broadcasters.

C5.5.3 Type of user markets

The initial commissioning client (international broadcaster) and broadcaster/co-producer had a strong and direct role throughout the innovation trajectory. The broad casters knew their audiences well and through their commentary on initial designs, scripts and various takes they influenced the content of the show. Some of the comments focussed on the "correctness" of the content for their audience but they would also contribute positive ideas as to what would be funny etc.. The eventual end-user, the pre-school children audiences played a very limited direct role. The company didn't test their initial ideas or trailer on the client group. "We did not have the luxury." (Interview executive producer). One of the first broadcasters did test the show twice on their audience. Although this provided information about the age of the children that liked the show most and what elements are most liked by different genders, it did not influence the content of the show.

C5.6 INSTITUTIONAL CONTEXT

C5.6.1 Associational Networks

The company was established in 1999 as a very small enterprise by four animation students in their final year of college. The group had secured a very small grant from the national employment and training agency (Fas) to work on a film trailer over the summer. Although small, the Fas grant was instrumental in forging the initial coalition between the students, which would lead to the establishment of the company.

The Irish Film Board is a governmental body supporting the Irish film industry, partly through funding of development, production and distribution of films. The development phase of the Kicko series was crucially facilitated by a 30,000 Euro development loan from the Irish Film Board which allowed them to develop a trailer. It is unlikely that the start-up company would have developed the series without it. "I think it would've been really difficult because we would not have had that development money. Where would we have got it? Most companies who develop shows are big companies and they have the [resources] to put into development." (Interview executive producer). Similarly the company strongly benefited from Ireland's tax system, notably section 481 tax credits.

At the start of the innovation trajectory in 2002, KilAnim was still relatively weakly networked in the national and international animation scene. It was also weakly embedded in networks of formal or semi-formal associations. The company did frequent the annual international trade fairs and festivals (e.g. MIPCOM, MIP Junior; KidScreen, MIFA) organised by international associations. Staff members did use and contribute to online international forums such as *Animation World*, an international on-line animation community. The national animation scene was small and the most important contact points for KilAnim to meet other members of the Irish community were the annual trade fairs and festivals.

This situation appears to have changed somewhat over the six-year period since the inception of the show. The executive producer has become a member of the animation sub-committee of the Screen Producers Guild of Ireland[14]. The Guild was established in 2000 as a representative body for producers involved in the Irish and international audiovisual industry. The goal of the professional association is to support Irish screen directors and promote Irish directors on a national and international scale. The Guild meets a small number of times a year. The producer of the show mentioned that the Guild does facilitate the flow of knowledge (notably development related) among the Irish community but could not provide an example of how this had benefited KilAnim. In the opposite direction he had advised some members of the Guild in relation to the organisation of project pipelines.

The company has also become a member of the Irish Film and Television Academy (IFTA), a non-profit organisation that promotes and rewards creative excellence in film and television. The annual IFTA ward ceremony is the only formal event that the company frequents in Ireland. At the 2008 IFTA Awards, the company won best animation.

Enterprise Ireland, the national industrial promotion agency does manage the *AnimationIreland* web-site. The site functions as a promotion tool and knowledge repository for the Irish animation industry. The executive producer has also attended the animation CEO Forum which has been set-up by Enterprise Ireland. The relative importance of IFTA and Enterprise Ireland for knowledge flow and innovation is unclear. Enterprise Ireland does provide support for companies to visit international conferences and funds an Irish stand at some events but the company establishes its contacts and networks by itself.

C5.6.2 Forms of regulation

To an extent the content of the series is indirectly regulated by the fact that the client broadcasters experience a level of government and self-regulation.

C5.6.3 Finance

The company was established in 1999 as a very small enterprise by four animation students in their final year of college. The group had acquired a very small grant from the national employment and training agency to work on a film trailer over the summer. After this project the group decided to continue working together on other projects, notably web cards, and a company was established.

The innovation trajectory of bringing a new animation series from concept to market is relatively short. Still it requires substantial investments (6.8m Euro) that a small company, especially a young start-up firm, is unable to finance on its own.

The development phase of the Kicko series was crucially facilitated by a 30,000 Euro development loan (paid back on first day of principle animation of the series) from the Irish Film Board which allowed them to develop a trailer. The company also strongly benefited from Ireland's tax system, notably section 481 tax credits. This can provide a benefit of up to 28 per cent of eligible Irish expenditure. Still, the company could not act on its own as a sole producer of the television series. The Irish market and the

[14] There is a separate Guild for Directors, just for film and TV Directors

company were too small for raising the necessary finance. The company tends to look for additional international partners which can reduce the production costs and provide complementary finance. In addition, having an international partner can provide access to international co-production treaty finance.

In the end the project became a co-production involving KilAnim, a Dutch production/distribution company, an Irish post-production house and a large international broadcaster of children's programmes (BestBroadcasting). Although the show had been pre-sold to other TV channels worldwide, the large international broadcaster became a virtual co-producer on the basis of being the largest investor. A US based, licensing and merchandising rights company invested to exploit the licensing rights of the product. Most of the up-front funding in the project came from the International co-producer/broadcaster and from pre-sales. Interestingly, the international co-producers in Kicko did not bring in any tax related advantages. The co-operation with the Irish animation and film production company TeleEire did bring additional tax and financial advantages due to the fact that the company was located in *The Gaeltacht* region of Ireland which offers further (regional development related) funding.

12 CASE STUDY 6

DEVELOPMENT AND PRODUCTION OF 2D COMPUTER ANIMATED CHILDREN'S TELEVISION SERIES - (ELI)

C6.1 OVERVIEW

This case study concerns the development of an innovative idea for an animated television series called 'Eli'. The series is aimed at young children and is based around a young character that discovers how key inventions occur throughout history and their links to nature with the tagline "nature got there first".

The main stages in the innovation trajectory for an animated television series of 20 X 11 minute episodes are conception, pre-production, production and post-production. If successful, a production can go into a second series and pre-production and production starts again. This case follows the innovation trajectory from concept development to pre-production. At the time of interview the pre-production stage had just been completed, final financing was being put in place and it was envisaged that full production would begin in early 2009. Concept development and pre-production took almost six years. During this time they were working on a number of other projects some of which have been completed.

The development stage includes a business development/financing component and a creative (read artistic) component. The original idea/concept for the show Eli was developed in 2003 by KDub, a small Irish animation company, as a 2-minute short pitch for business for a client. The client wanted to use animation to demonstrate how the idea for the computer developed. The pitch was unsuccessful but two directors at KDub liked the idea and decided to develop it alongside their other projects. One of the directors recalls how the two MDs felt the original designs for the project were too generic and so they met in work one weekend and went online searching for new talent and styles. The company had engaged four different designers to come up with the look and feel of the show at that stage. Their online search uncovered work by an Irish designer who had sent in a sample of work unsolicited and it had been saved. This freelance designer was invited to submit some concepts and he delivered six designs, one of which was deemed appropriate. This freelancer was hired full time in January 2004

The core innovations in Eli are the idea/story for the animation, particularly the link between nature and science, and the look/design of the main character and the environment which is set in the Bronze Age in a Celtic/Irish context. The first aspect was largely developed internally in the company in response to a call for ideas from the original client but the second came from the freelance designer.

Securing full development funding required the team to develop a full animated series specification book (also called a bible). In addition a pilot (about €40,000 is needed to produce these) and then presenting this pilot to potential funders (usually broadcasters

and distributors in other countries) at professional market events and in face to face meetings[15].

The company pitched a somewhat further developed concept to potential buyers at an international trade show, MIFA in Annecy, along with other ideas. MIFA is a forum/showcase event held in France each year which is attended by television broadcasters and distributors. Eli was among one of three ideas that garnered significant interest. Feedback from distributors ('they are the most in touch with the markets you know' Director) urged the team to address a younger market, make it more child-centered and to have a younger main character.

Feedback from one international broadcaster showed that some elements were suitable for their audiences and age demographics while others were not. The company met two people from CBeebies and their boss, the Head of Children's BBC. The BBC at this stage said they loved the look of it but it was too old for CBeebies which has a 4-7 years of age demographic. In addition, "the thing that worked for them was a scientific element to it and they have a remit as a public broadcaster to have certain amount of education. (Director.)

Developing the idea/concept and the subsequent production of the show was going to require substantial investments and much time during the development stage was devoted to raising finance, selling the show and forging co-production, distribution and licensing partnerships. Producing an animated television series of 52 times 11 minute episodes costs around €5m and this funding must be in place before the team can start production.

The company made six applications for pre-production funding between 2004 and 2006 for Eli to the Irish Film Board animation development fund, amongst others. All were unsuccessful. Finally, they got development funding from the Irish Film Board. A new person had been hired by the Film Board from the BBC and this person was interested in commissioning animation projects.

The Irish Film Board funding allowed the team to bring a more developed 1-minute pilot and associated promotional materials to Cartoon Forum, another professional market event in 2006. All the development was done in-house for this pilot. A key challenge at this stage was translating some of the scientific ideas into something that a 5-year-old could understand and making that visually interesting. They also got Enterprise Ireland funding to attend Cartoon Forum. 3-4 Irish companies attend this event on average each year. There are only 60 presentation slots of 15 minutes each for all European animation companies and you have to be selected to present.

The pitch at Cartoon Forum proved a breakthrough. RTE, the Irish public broadcaster came on board and gave a guarantee to screen the project (pre-sales) and a €50,000 advance payment. This was sufficient to secure development funding of up to 10.4% of development costs (producer equity) under the newly developed 'Sound and Vision' fund from the Broadcasting Commission of Ireland. This fund was set up to

[15] The key professional fora for companies to pitch broadcast ideas in Europe are MIFA, Annecy, France and MIP TV, Cannes, also in France[15]. The EU supported Cartoon Forum is another market where animation producers can find buyers and co-producers. In the United States Kid Screen in New York is one of the key professional events.

fund ‘culturally appropriate’ projects and all terrestrial broadcasting companies could apply for funding which comes from the license fee. The BCI were keen to address the fact that the majority of animation shown on RTE was bought in from the United States

In late 2008, BBC Worldwide signed up as a distributor (percentage funding) alongside CopCan, a Canadian company based in Nova Scotia who will also be involved as a co-producer. The production network now stretches from Dublin to London and to Canada. They choose a co-producer in Nova Scotia because they can get funding through labour credits in Canada for creating employment there. The final part of the financial puzzle is to secure section 481 tax credit status in Ireland to get tax back on the production.

At the time of interview the project was ready to go into full scale production of the first 20 X 11 minute episodes once section 481 status was secured. A further 32 X 11 minute episodes is envisaged but a further €1 million would be needed for the second series. The contract/business person was also about to start negotiating merchandising and ancillary rights deals. In February 2009 company staff attended Kid Screen in New York in search of these additional deals.

The production stage started later 2008 with an increased involvement of the Canadian co-producer. The Canadian team will take care of most of the production and post-production activities. The series is set to air in early 2010 on RTE, Ireland and in March 2010 on BBC UK/Cbeebies

We distinguish four different stages in the innovation trajectory.

1 Concept Development.
2 Pre-production
3 Production
4 Post production

C6.2 PATTERNS OF KNOWLEDGE FLOW AND INNOVATION

C6.2.1 Type of Actors and their Location

The original concept and idea for the show was developed by KDub, a small Irish animation company of ten employees based in Dublin which focuses on animations for television and cinema. The company develops original ideas/intellectual properties, develops them and sources the development and production funding in the marketplace. Their core strengths are, as they see it, in original script and idea development, character and environment design and putting together a production team and funding. Their focus is on pre-production of animated concepts, putting together funding for production and organizing a production network and distribution. They tend to outsource production and the actual animation process to co-producers elsewhere.

The company was incorporated in 2001 by three friends who had been at college in Ballyfermot together where they had studied animation and where they had later worked as part time lecturers. Only one of the original three is still in the company although the two directors and the art director have all attended Ballyfermot. As a

relatively young company they have brought a small number of film and television projects to completion working with companies in Northern Ireland, Canada and elsewhere. Previous projects have included: a short film adaptation of book about being a hostage in Beirut, and **a** 52 x 5 minute show for 4-7 years produced with a studio in Northern Ireland. The team has also previously done service work, one project for a major US network and one for a major Irish e-learning company. Both these projects provided marginal profits which assisted to the development of their own internal concepts. During the latter project the team grew from 10-54 for a period of eight months. At the time of interviewing the company had contracted back to 10 full time staff.

Developing the concept for an animated television series is done by artists and designers. This concept is then developed over time with input from subject and market experts. At concept development stage a small number of staff, 1-2, work on the idea. Concept design can take place anywhere and artists may be full time in-house staff or freelancers working from home. The concept design on this project seemed to be done by one internal person primarily while the character design was done by a freelance artist (‘a floating resource’ Director.) who had originally cold called the company sending in examples of work by e-mail. Interestingly he comes from a similar background and training to the other main employees in the company and is Irish. He is now employed full time on the Eli project.

Development funding from the Irish Film Board was used to enlarge the team by adding more artists to work on character and environment design and a writer to work on the script and scenarios for episodes. In 2008 finance and the core production team were in place. The core partnership involves of the KDub in Dublin (co-producer) CopCan in Halifax, Canada (co-producer and responsible of animation production during the production stage), the BBC Worldwide and Picture Box in Canada (both acting as distributors). The sales and distribution activities continue during the subsequent stages of the innovation trajectory. The company directors will continue taking the show to major professional market events to sell additional territory and merchandising rights and to raise money for the second series. The BBC only took entertainment rights (TV and DVD) and there are another 50 areas of rights they could potentially sell on, including book publishing, merchandising etc.

Most of the pre-production activities were conducted by KDub in Dublin that will also have the control over the production content and process. The Dublin team was still relatively small (under 10). Activities focused on design and scripting. The two main script writers are based in the UK and have extensive experience writing for children’s television and the BBC. The BBC is involved by doing quality checks on the scripts and animatics before they are animated. Voice acting and recording is done in Ireland although a British accent coach was employed to make sure that certain Irish pronunciations would be understandable for the core UK audience.

The production stage started end-2008 with an increased involvement of the Canadian co-producer. The Canadian team will grow and focus and focus on animating the designs. The larger team in Canada will allow the production to take advantage of labour credits offered by the Canadian government as well as cheaper labour costs in Canada. Post production will be conducted in the Canadian studios as well

C6.2.2 Sources of Knowledge

The original idea for Eli was developed as a 2 minute animated short 'pitch' for work in 2003. Thus the concept was developed in relation to a problem presented by a client but the company had full creative control over the concept. The client wanted to use animation to demonstrate how the idea for the computer developed. The pitch was unsuccessful but the team liked the idea and decided to develop it alongside their other projects. At this stage the idea was very much internally developed by company staff and based on what they liked, not the market or audiences. Indeed it would appear that one of the company directors is the main project champion and retains to a large degree the overall say on the design and aesthetics of the show. The company sourced knowledge externally in the form of a freelance Irish artist who produced the initial character design for the show. He later came on board as the main artist.

The main sources of knowledge during the early development stage are the embodied knowledge and inspiration of the artists, partly developed during their education, on-line image search, books, and their local (Irish) cultural background. The initial artists has expanded the content and moved it in the Bronze Age because they had all done art history in college and 'loved the kind of metal work and you know the architecture and everything that went on there. It was a kind of golden age really, in this country anyway. … they discovered all these technologies but there was a lot of art in it, and there was also balance, it was quite ecumenical, it was a balance of nature, coming from their beliefs … and so we thought there's a metaphor in here for, like how we can balance out life in the 21st century' (Director). They conducted online and book based research using popular science sources.

The main artist described how he came up with the design as "I would sort of get a piece of paper in front of me, get a pencil and just brainstorm, just try and interpret what A had asked me to do." (Int. Art Director) He went on to say he did a bit of research on costume and designs from the Bronze Age using the internet (Google image search), and books. If he gets a creative block he takes out some art books or browses some art blogs online just to get some ideas and inspiration. He described the style as flat, pop-up book style. Influenced by animation from the 1950s and 1960s, a style that was a reaction to Disney at the time. He decided on colour, teeth, eyeballs and all the details. The rule of three is important to the show as it was important to the Celts and so in the show things occur in threes. He also draws upon children's books, illustrations and cartoons that are out in the market for ideas. CBeebies from the BBC and Nickelodeon in the United States would be key target channels for animated television series and thus are watched by the team to keep up to date with animation fashions.

Internet blogs are clearly an important source of inspiration. Key blogs include the US hosted *http://www.drawingboard.org* although an Irish site *http://www.scamp.ie* is consulted as well for this purpose. Here artists can post work, obtain crits and opinions and show work. The communication of crits and opinions electronically with peers is valued highly. "I think the internet is probably one of the best tools an illustrator can use. I'm sort of remembering a few art forums on the Internet so I get to show my work on these art forums where illustrators and artists from all over the world use. So I know these people through email. Like I have never physically met them or spoken to them but I would know them. Like I have had electronic conversations with them." (Int. Art Director.)

The internal team and company environment also appears to be important to spurring on their creativity. The main art director pointed to the differences between working as a freelancer and relying on electronic communication as compared to the creative buzz of working in a creative environment/company. “If you are in a creative environment, you are sort of buzzing off other people, in that respect I mean I have found that…when I was working on my own, my work somewhere a bit stale because I was…and there was no other people giving any input.’ (Int. Art Director) He also noted the creative influence of Dublin. “I think it is a nice place for an illustrator because I think there is a lot, a lot of inspiration you know […] there is great things to looks at everywhere.” (Interview main artist)

Some of the know how related to core software packages and tools (Photoshop, Flash and 3D Studio Max) was obtained in college but interviewees noted that artists largely learnt by trial and error and doing on the job. These packages are constantly updated and expanded. Production and business skills are also learnt on the job and the key producers admitted they had never been trained to manage or produce large projects, their training was as artists, designers and animators.

During the early development stage the company enjoyed some feedback from potential distributors and broadcasters at the international trade fairs and events. Feedback from distributors (‘they are the most in touch with the markets you know’ Director) urged the team to address a younger market, make it more child-centered and to have a younger main character. Feedback from one international broadcaster showed that some elements were suitable for their audiences and age demographics wile others were not. The company met two people from CBeebies and their boss, the Head of Children’s BBC. The BBC at this stage said they loved the look of it but it was too old for CBeebies which has a 4-7 years of age demographic.

Know who type knowledge is particularly important during the development stage for finding partners clients and core crew. The main source of know who type knowledge are the professional international market events like MIFA, MIP TV and Kid Screen and it is interesting to note the wide variety of companies from around the world, including Korea, Japan and China, who show work at these events. Over the years, the regular attendance of such events in combination with experience in an increasing amount of projects expands the knowledge embodied in the core staff or recorded on the company’s “list” (see under finding partners), which becomes an increasingly important source. The partners are also an important source where co-producers or distributors have identified additional partners. Finally International and, to a lesser extent, Irish internet sites do play an important role in identifying core staff and crew (see under finding partners).

The case study (see under finding partners section) suggests that the young age of the firm may have been of some influence on their know who type knowledge. KDub was incorporated in 2001. During the development stage of this innovation trajectory the company was relatively new to the scene and their network and know who type knowledge were still very much in development. At the time of interview, the company was seven years old. Through visiting the international trade-shows and experience in additional projects the company’s know who type knowledge and access to potential partners and clients had greatly expanded

During the pre-production stage the artists at KDub rely by and large on similar sources of knowledge as during the development stage. The two UK-based script writers represent an important additional source. In addition, the art director does receive suggestions and ideas from the Canadian team, especially in areas where he is not an expert. Although the company undertook some small scale testing of ideas on children in Irish schools, knowledge of the audience is largely mediated through the client broadcasters and distributor/co-producer rather than gathered directly from the audience. The show had to conform to internal BBC house rules.

C6.2.3 Finding Partners

A number of events seemed to occur at this time which enabled this project to move towards production. These events involved the appointment of new staff in RTE and the Irish Film Board, the development of personal relationships with these staff members and the establishment of a new funding programme in Ireland. More specifically these new staff had international experience, one had moved from the BBC and the new person in RTE specifically wanted to finance more Irish animation. These shifts were identified and tapped into through informal networking at an international animation market event in France. The pilot production, the development of personal relationships and the development of a new fund together enabled core production finance to be secured from RTE and the Sound and Vision Fund and this in turn helped to bring on board the main English speaking public service broadcaster in Europe (the BBC) and secure a co-production partner in Canada which brought funding from another territory to the project.

First contact with the main co-producers and clients was established during the annual international trade fairs and events. Both the RTE and BBC showed interest in the project at Cartoon Forum. Interestingly it was difficult for the company to get time with RTE in Dublin but during the evenings at Cartoon Forum it was easier. “It is hard to get a meeting with them in Dublin […] it is really hard to get a meeting with them normally because they are so busy. When they are at this thing like they work hard during the day but then they have got leisure time in the evening and that is when you meet. The Irish tend to kind of club together, usual stuff you know and you know, you would get to talk to people, you would have a few drinks. You would be relaxed. Suddenly, you know, they don’t have another meeting in ten minutes and that is when you start kind of developing a relationship and after that it is kind of easier to get a meeting because they know what you are about you know. (Interview Director) The Producer reiterated this and noted that “it’s real personal.”

The Canadian co-producer was introduced to KDub by a distributor in Canada who later pulled out of the project. The company has not previously worked with the Canadian partner but they liked their work. They have met them at international conferences and get on well.

The Director spoke of how the company had developed an extensive list of contacts whose work they liked. These links were made and developed at international conferences/markets and social events as well as from cold calling from freelancers. “We have been going out to these markets for the last five, six years now, we built up an extensive network, we gotten to know people, we have seen people go, we have

seen them develop. Certain individuals who [weren't my first choice] to work with five years ago are now great people and we want to work with them. We tend to kind of refresh relationships all the time so that we can say, look there is going to be a project that comes along that suits us both and then we'll maybe work together. We literally know hundreds and hundreds of contacts in that respect. We got a hit list of five or six people who we want to do business with over the next ten years." (Director). The company has also used online professional networking software like *Plaxo* and *Linked In*.

The above sections suggest that the young age of the firm may have been of some influence on the way they find external partners. KDub was incorporated in 2001. During the development stage of this innovation trajectory the company was relatively new to the scene and their network and know-who type knowledge were still very much in development. For example, the company had no direct access to the Irish national broadcaster. At the time of interview, the company was seven years old. Through visiting the international trade-shows and experience in additional projects the company's know who type knowledge and access to potential partners and clients had greatly expanded

Core staff and crew were identified using the same list or contact as well as the through internet search. One of the directors recalls how the two MDs felt the original designs for the project were too generic and so they met in work one weekend and went online searching for new talent and styles. The company had engaged four different designers to come up with the look and feel of the show at that stage. Their online search uncovered work by an Irish designer who had sent in a sample of work unsolicited and it had been saved. This freelance designer had originally cold called the company sending in by e-mail examples of work. He was invited to submit some concepts and he delivered six designs, one of which was deemed appropriate. This freelancer was subsequently hired full time.

Freelance crew, from their side, does take an active approach in the identification process by constantly nurturing their visibility to the animation world. In this respect, the most important resources are the international internet forums. "I think the internet is probably one of the best tools an illustrator can use. I'm sort of remembering a few art forums on the Internet so I get to show my work on these art forums where illustrators and artists from all over the world use. So I know these people through email. Like I have never physically met them or spoken to them but I would know them. Like I have had electronic conversations with them." (Int. Art Director.) There is an Irish blog as well but this appears less important for securing work. "I mean, I think, today you really can't concentrate on one country. I mean, I have got most of my work from other countries rather than Ireland." It is hard to get jobs in France because they have a lot of 'super-talented French illustrators' but he has worked for companies in China, Germany, the UK and the US.

C6.2.4 Mode of Knowledge Exchange, Proximity and Level of Intentionality

The core partnership involves KDub in Dublin (co-producer) CopCan in Halifax, Canada (co-producer and responsible of animation production during the production stage), the BBC in London and Picture Box in Canada (both acting as distributors) and RTE (first client). Since most of the creative (artistic) development activities were conducted in-house by KDub, this involved little communication. Most

communication with external partners at this stage concerns the development of co-production, distribution and sales agreements. Much of this communication is conducted face-to-face, initially during the international trade fairs and events followed by intensive electronic communication and, though not always, a face-to-face meeting at the offices of one of the partners or clients. Interestingly the BBC had never been to the Dublin studio and neither had the large US broadcaster they had worked with previously. These relationships were built up at face-t- face meetings at the major market events and sustained by electronic communications.

Partner choice appears insensitive to distance decay. Geographically distributed co-productions are common in the animation field due to the need to secure sufficient funding for projects across different territories/markets and the need to reduce labour costs in a production process which is labour and computer intensive. Co-producers are chosen based on their internal skills, track record of productions and the financing they can bring to the project. There is also an element of cultural compatibility although experience of working together can help to negate this.

KDub are relatively new to co-productions and this is only their second one. They admit that they are learning by doing. For Eli they considered worked with a studio in the Philippines, in India and in China but they opted for the Canadian studio 'which was the higher cost but we felt that they had the correct sensibilities you know, we are going to be making our first show so we have to make sure….. we want to make sure that culturally and everything else that we are on the same page.' (Director). The skills of the Canadian co-producer are a good fit with the Dublin teams as the focus on service work, not original idea creation. Their core strengths were the quality of their work and the fact that they could secure tax credits in Canada.

With the transition to pre-production the communication with the Canadian co-producer intensifies. This concerns creative as well as co-ordination issues. While initially there were one or two site visits, most of the communication takes place electronically. There is a budget for meeting face to face but this is only used if there are major issues. For the art director there were weekly conference call meetings of the main producers and director and then more regular, daily communication with the artists in Canada via e-mail and telephone. They send him examples of work and he comments, checks for mistakes and checks they are keeping to the style bible. Comments are drawn over the work using Photoshop and sent back as PDF files. Conference calls use speaker phones rather than video.

Interestingly, the art director at KDub appears to prefer electronic communication over face-to-face meetings to communicate aesthetic issues. he prefers to comment on work done in Canada by drawing on it using Photoshop and writing an e-mail which he argues one can be concise, re-read what is written and make things clearer than on the telephone. "I also found if I have points on screen in front of me or on paper, I can always go back to them, because I think if you speak to somebody face to face and you are asking them to change a number of things, a lot of things can be forgotten." (Int. Art Director)

Both teams in Dublin and Canada use similar hardware and software to produce their drawings and designs. While the skills to use these technologies are relatively codified

the outputs from them can vary widely in design and aesthetics and thus regular communication is needed to keep the aesthetic style uniform.

Most of the communication is intentional and it is hard to discover the level of unintentional knowledge flow based on interviews. Where unintentional knowledge flow is clearly obvious is in international professional events – MIP TV, MIP Com, Kid Screen, Cartoon Forum which are central in terms of developing relationships and linking into the international animation community. One of the directors noted that about 40% of the work happens in the evenings during the social events and that if you go to these events consistently it has a 'domino effect'. Further unintentional information exchange and know how type knowledge is mediated by internet forums.

There is some evidence of the unintentional flow of inspiration type knowledge. Here we can point to the creative influence of Dublin. "I think it is a nice place for an illustrator because I think there is a lot, a lot of inspiration you know […] there is great things to looks at everywhere." (Interview main artist). Other unintentional information exchange occurs among staff within KDub. "If you are in a creative environment, you are sort of buzzing off other people, in that respect I mean I have found that…when I was working on my own, my work somewhere a bit stale because I was…and there was no other people giving any input.' (Int. Art Director)

The unintentional knowledge flow through 'buzz' operates at international, virtual and, to a lesser extent national/local level. The national/local level includes a number of sites for potential 'buzz' that are visited by KDub staff. We can again point to the general creative environment of Dublin and the unintentional information flow among staff within KDub, although it is arguable whether this should be interpreted as buzz (it does not cross the boundaries of the firm). The main artist is a member of the Irish Guild of Illustrators which he meets informally once a year. The Irish animation blog *http://www.scamp.ie and the websites* and the website of for Irish animation companies (http://www.animationireland.com) can be regarded as virtual local buzz. These sites are however less important for knowledge flow than the international blogs and sites. There are currently 12 companies listed on the *Animation Ireland* site.

The interviews suggest that an Irish community does exist and that this may stimulate intentional and unintentional information flow and buzz. However, the most important sites for knowledge flow are international and virtual and only secondary local. This may be illustrated with the way how business networks are formed. First contact with the main co-producers and clients was established during the annual international trade fairs and events. Interestingly it was difficult for the company to get time with RTE in Dublin but during the evenings at Cartoon Forum it was easier. "It is hard to get a meeting with them in Dublin […] it is really hard to get a meeting with them normally because they are so busy. When they are at this thing like they work hard during the day but then they have got leisure time in the evening and that is when you meet. The Irish tend to kind of club together, usual stuff you know and you know, you would get to talk to people, you would have a few drinks. You would be relaxed. Suddenly, you know, they don't have another meeting in ten minutes and that is when you start kind of developing a relationship and after that it is kind of easier to get a meeting because they know what you are about you know. (Interview Director).

At the international trade fairs and events "There is a scene for producers … a scene between UK companies and Irish companies and Canada and that would purely be through the networking and years going to France and meeting up and keep in touch but there is not an actual official you know." (Int. Producer)

KDub uses a number of digital environments for external knowledge exchange and project management. The company uses 'Basecamp' version control software/project management over the internet to communicate and collaborate with their Canadian partner (http://www.basecamphq.com/)[16]. This is a proprietary project management software programme.

They also use telephone conference calls, skype and e-mail extensively. The systems are separate and the lead artist stated that there could be some advantage in keeping communications for each project in one programme and one place. This is especially the case when there is more than one project in production. Key problems with the current system involve speed of transfer and things not transferring properly. Other important digital environments include the artists websites, blogs, forums and Google image search. Artists seem to prefer engaging with professional sites rather than just searching randomly on the internet. The communication of crits and opinions on work is valued highly and they are used to gain 'exposure'.

Finally there are important online systems in place at the international professional events – MIP TV, MIP Com, KidScreen, Cartoon Forum. These events have systems which are a type of 'relationship mediator' and a range of online resources allow attendees to contact key buyers in broadcasters and distributors, information that is not available elsewhere. This is a key added value of the professional markets.

C6.2.5 Importance of the Region / Ireland

The main advantage of the location in Dublin or Ireland lies in the fiscal and financial incentives on offer. Most of the core actors and partners in this project are located overseas. Although the first client was the national broadcaster, the main markets for the show are international. The national broadcaster has only a recent history of commissioning children's animation series. Although a Dublin location, in proximity to the main international airport may facilitate contact with international clients, neither the BBC nor the large US broadcaster they had worked with previously had ever been to the Dublin studio. These relationships were built up at the professional market events.

The main sources of knowledge are global or virtual. The potential sites of "buzz" in Ireland are limited and don't appear salient for knowledge flow. The Irish community may well constitute a vehicle for intentional and unintentional information flow and buzz. However, the most important sites for knowledge flow are international and virtual and only secondary local.

There is some evidence that the Dublin environment provides an inspirational environment for the artists. For the art director living in Dublin was important both

[16] Basecamp is a pay-as-you-go service. There are no long term contracts of commitments on your part. You simply pay month-to-month.

personally and creatively. 'I mean I've here all my life and it's just, it's just convenient…. There is a good art scene here and there seems to be based here, I mean there's another in Kilkenny as well, which seems to be pretty vibrant as well, but I think Dublin is a good city for that kind of way. […] there seems to be a nice acceptance of alternative art in Dublin which I think is nice and I suppose I just love the architecture of the city as well. […] I think it is a nice place for an illustrator because I think there is a lot of inspiration you know […] there is great things to looks at everywhere." (Interview main artist)

Another interviewee suggested that, for their type of work, they did not really have to be in the centre of Dublin but that it helped to source 'talent' both in Ireland and from abroad.

The company had been based in the Digital Depot, part of the Digital Hub. The Digital Hub is the main concentration of digital media companies in Ireland. It is the result of a government initiative to spatially concentrate digital media companies in a particular area of Dublin in the hope to create cluster-related advantages. Because of this particular location KDub had benefited from the cheap rent, the incubation space a high connectivity and support. However they had not really benefited from networking with other digital media companies in the Hub. They also found the location and environment not very conducive to doing their type of business.

C6.3 TYPE OF KNOWLEDGE CREATION

The first three stages of the project (development, pre-production, production) have been dominated by the symbolic knowledge base. The core creative (artistic) innovations are the idea/story for the animation, particularly the link between nature and science, and the look/design of the main character and the environment which is set in the Bronze Age in a Celtic/Irish context. A key challenge during the concept development ages was translating some of the scientific ideas into something that a 5-year-old could understand and making that visually interesting. As such the project and its outputs are about creating and designing new ideas and images and metaphors. "The Bronze Age was a kind of golden age really, in this country anyway. They discovered all these technologies but there was a lot of art in it, and there was also balance, it was quite ecumenical, it was a balance of nature, coming from their beliefs … and so we thought there is a metaphor in here for, like, how we can balance out life in the 21st century" (Director).

Technologies are used as tools to draw and design with or for communicating and networking but they are not the core/base of the innovation which is an idea and a drawing.

The core knowledge base of the concept team is design orientated and based on classical animation, drawing skills and ideas for episodes. Initially the team decide themselves if the concept works or not based on their own aesthetic sensibility. The conceptualization part of the process is about getting the project to work aesthetically and in terms of the meaning of the content i.e. semantically.

The core design team's main activities or mode of working involves searching, reflection and interacting. Idea creation draws upon past experience, trial and error, sketches and iterations, sitting and thinking with a blank page, staring out the window, research online and in books. There is a lot of talk of 'gut feeling', 'knowing what we want', 'developing stuff we liked', 'getting the look right'. The main artist described how he came up with the design as "I would sort of get a piece of paper in front of me, get a pencil and just brainstorm, just try and interpret what A had asked me to do." (Int. Art Director) He went on to say he did a bit of research on costume and designs from the Bronze Age using the internet (Google image search),

Knowledge inputs are of an aesthetic nature and demand ability in symbol interpretation. Core knowledge inputs during the early phases include embodied knowledge and inspiration of the artists, partly developed during their education, on-line image search, books, and their local (Irish) cultural background. A good example of a symbolic knowledge input is "the rule of three" which is important to the show as it was important to the Celts and so in the show things occur in threes. He also draws upon children's books, illustrations and cartoons that are out in the market for ideas. Context appears to play a role in terms of the innovation in this project and in terms of the organizational culture. There was an element of 'keeping it Irish', in terms of accents and the Celtic themes. CBeebies from the BBC and Nickelodeon in the United States would be key target channels for animated television series and thus are watched by the team to keep up to date with animation fashions.

The activities, notably during the first two stages rely strongly on tacit knowledge. Codified knowledge plays a limited part. They do not read academic science journals or magazines because "I am not sort of wired that way to understand the academic side of it" and you have to be able to visualize it for children. They read popular science books, watch competitor's productions, trawl through online resources and databases. Know how based on experience is far more important then know why and on the company's website the activities are referred to as 'craft'.

The core generic skills like drawing etc. were learnt in college. Knowledge of core industry standard software packages and tools including Photoshop, Flash and 3D Studio Max, was introduced in college but interviewees noted that they largely learnt by trial and error and doing. The main artist is self-trained in the programme and learnt by 'trial and error'. He admits he probably only uses about 10% of the programme and if it has his favorite brushes and tools he can use an old version.. Production and business skills are also learnt on the job and the key producers admitted they had never been trained to manage or produce large projects, their training was as artists, designers and animators.
Before the project can move into pre-production and production the concept must be compared to competing products in the marketplace and presented to potential buyers or clients. In addition the project will involve a range of external partners and a key element during the development stage is knowing who to interact with. Interviewees talk about 'developing relationships' and using these relationships at the appropriate time, 'a question of timing'. It is import to choose the right partners, since the interactions with these actors crucially influences how the concept is translated into a marketable product. The external actors provide market information and act as market intermediaries. The role/say of these actors is not necessarily dependent on how much funding they are bringing to the project. The BBC for example has a very influential

role in this project even though they are not putting in the largest amount of money. Much of their input is checking that the content is appropriate for a public service broadcaster, in line with their charter as laid down by the UK government and is appropriate for their audience. Similarly, the script writers are allowed a lot of input, given their writing experience with the BBC and the fact that one has a science and teaching background.

During pre-production a lot of focus is on further developing an overall style and look of the project and putting processes in place. The key actors are both internal and external to the company. During production the concepts, designs and processes have largely stabilized and the focus is on maintaining consistency and quality of production. The production team is now more distributed and involves artists and designers in Dublin and Canada supplemented with experts in the UK and elsewhere in Ireland.

Table C6.1: Modes of knowledge creation, location of actors and intensity of face-to-face contact – 2D animated TV series (Eli)

	Dominant mode of knowledge creation	Location Actors	*Sources of knowledge (in order of importance)*	*Inter institutional face-to-face contact (frequency and number of people involved)*
1) Development	Symbolic	(focal) Production company Ireland; Co-producer Canada; Distributor UK and Canada Broadcaster Ireland	*For know who type knowledge:* Founding members, based on visiting trade fairs and (later) engagement in previous projects; Co-producer and distributors; Internet sites *For general ideas and inspiration:* Embodied knowledge and inspiration of the artists; Children's books; illustrations and cartoons; internet blogs; Dublin as an inspiring environment *For specific creative ideas*: On-line and book base popular science sources, feedback broadcaster and distributor *For know how type knowledge* Software manuals	*For know who type knowledge* Global: 3-5 times a year (trade fairs) Local (Ireland): None. *For project content and co-ordination* Global: one initial site visit at Canadian co-producer. Keeping in touch during events. Local (broadcaster client): Once
2) Pre-Production	Symbolic	(focal) Production company Ireland Co-producer Canada Script writers UK	As above but UK script writers and Canadian co-producer become an additional source of ideas and know how;	Global: One initial site visit at Canadian company. Local (Broadcaster client): No data.
3) Production	Symbolic/Synthetic	Co-producer Canada; (focal) production company Ireland	As above but Canadian co-producer becomes an even more important source of know how	Global: None with Canadian. Local (Broadcaster client): No data.
4) Post-Production	No data	Co-producer Canada; (focal) Production company Ireland	No data	No data

C6.4 THE ORGANISATION OF KNOWLEDGE COMMUNITIES AND CENTRAL OCCUPATIONAL GROUP

C6.4.1 Occupational Groups

One can identify an artistic/design community which the company feels part of and which is both local and international. The two joint managing directors and the main artist come from a similar background and training and all-self describe as ‘creatives’ and ‘you are kind of fighting your gods there to try and stop being creative’ (Int. Producer.). However they have adopted different roles in the company, one is predominantly creative, one predominantly produces and one is the art director. Externally, the geographically distributed production team is largely professionally in the same design/creative cognitive space.

C6.4.2 Heterarchical and Hierarchical Knowledge Flows

Given that most of the team in Dublin are artists and have a similar training they tend to communicate freely with each other about problems and issues. This is not to say that there have not been problems. Interviewee 1 talked about working with various designers where things did not work out and how the first two partners in the company left. They declined to go into detail about what happened in these cases.

Regarding the inter-firm level, the staff in Canada and in Dublin are all trained artists and while there were some disagreements there appears to be few issues communicating. Disagreements have occurred over the extent to which the programme should be 2D or the more modern 3D. This issue was resolved with reference to another actor, namely the main distributor and broadcaster, BBC / BBC Worldwide, who expressed a preference for 2D. Other issues arose over inconsistency of design and replicating the original style. The team in Canada deferred to the art director in Dublin on this who in turn turned to the executive director/project champion in Dublin where necessary. At times it would appear that the team resolves key issues in quite a hierarchical manner, but at other times the art director is willing to take suggestions from the Canadian team, especially in areas where he is not an expert. Some ideas have come from the Canadian team and been incorporated into the production so the flow is not all one way, although control is still centered in Dublin.

C6.4.3 Organisation of Knowledge Communities

One can identify an artistic/design community which the company feels part of and which is both local and international. The two joint managing directors and the main artist all self describe as ‘creatives’ and ‘you are kind of fighting your gods there to try and stop being creative’ (Int. Producer.). However they have adopted different roles in the company, one is predominantly creative, one predominantly produces and one is the art director. They are keen to develop more structured and distinct roles but it would appear that as yet they are quite fluid. Production is something they have had to learn on the job.

To an extent the knowledge community is organized on the basis of educational specialisation. Most artists had enjoyed some type of animation or art background. A substantial part of Irish staff even came from the same college. KDub was incorporated in 2001 by three friends who had been at college in Ballyfermot together where they had studied animation and where they had later worked as part time lecturers. Only one of the original three is still in the company. The main artist also went to Ballyfermot when the director was a teacher there but they did not really know each other.

In the Irish context being a Ballyfermot graduate is an identity badge. The focus on drawing and artistic skills as opposed to purely 3D animation training has been a significant strength of the graduates over the years and this currency is known by companies who hire the graduates. It is also significant that many of the Irish owned animation studios in Dublin were founded by graduates of Ballyfermot. KDub does however not maintain ongoing links with universities or colleges although there is clearly a sense of collegiality since the core of the team all attended the same college and were all trained in the same way.

The most important sources of knowledge are the international trade fairs and events where people with different skills and functions mix. The role of the international professional events – MIP TV, MIP Com, KidScreen, Cartoon Forum is important in terms of developing relationships and linking into the international animation community. These events are relationship mediators of a type and a range of online resources allow attendees to contact key buyers in broadcasters and distributors, information that is not available elsewhere.

Some of the virtual sources of knowledge cater for all functions while others are organized by sub-function. Key artistic blogs are http://www.scamp.ie and http://www.drawingboard.org where artists can post work, obtain crits and opinions and show work. There is a website for Irish animation companies called http://www.animationireland.com The main artist is a member of the Irish Guild of Illustrators. He is also on the Creative Ireland website.

“I think the internet is probably one of the best tools an illustrator can use. I’m sort of remembering a few art forums on the Internet so I get to show my work on these art forums where illustrators and artists from all over the world use. So I know these people through email. Like I have never physically met them or spoken to them but I would know them. Like I have had electronic conversations with them.” (Int. Art Director.)

C6.5 ORGANISATION OF FIRMS AND MARKETS

C6.5.1 Organisation of Firms

CopCan has about 20 people working for them in Canada and they tend to focus on service work, i.e. working on projects and concepts developed elsewhere. They start at two o’clock Irish time so there is a bit of staying late in Dublin to accommodate overlaps in time. KDub and the Copernicus work to a schedule (maintained in an excel spreadsheet) and payments are delivery dependent. There is a budget for meeting face to face but this is only used if there are major issues.

Scripts and the animatic have to be approved by the BBC and thus go through periodic quality controls. Both RTE and the BBC have a 'public service' charter and thus the educational and science element of the show fits their mandate. Some focus groups with children are carried out but relationships with audiences are mediated by the broadcasters and distributors.[17]

C6.5.2 The Size of Firms

KDub is a small company employing 10 full time staff, although this number can increase substantially when in production. During an earlier project the team grew to 54. Although the innovation trajectory of developing an animated television series is relatively short the investments are too sizeable for small animation companies to go it alone. Even the relatively small amount of finance required for the initial stages of development was too great for KDub. Therefore public funding and support from the public service broadcaster has been key to getting this and other projects into production. After this, the size of the Irish market and the structure of funding from some agencies means that company needs considerably investment from overseas to get to production. This generally includes a large foreign broadcaster or distribution company with the financial cloud to commission/finance projects and provide advance payments

CopCan, the Canadian co-producer has about 20 people working for them in Canada and they tend to focus on service work, i.e. working on projects and concepts developed elsewhere.

C6.5.3 The Age Profile of Firms

KDub was incorporated in 2001 by three friends who had been at college in Ballyfermot together where they had studied animation and where they had later worked as part time lecturers. Only one of the original three is still in the company. As a relatively young company they have brought a small number of film and television projects to completion working with companies in Northern Ireland, Canada and elsewhere. However, during the development stage of this innovation trajectory the company was relatively new to the scene and their network and know who type knowledge were still very much in development. For example, the company had no direct access to the Irish national broadcaster. At the time of interview, the company was seven years old. Through visiting the international trade-shows and experience in additional projects the company's know who type knowledge and access to potential partners and clients had greatly expanded.

C6.5.4 Type of User Markets

During the early development stage the company enjoyed some feedback from potential distributors and broadcasters at the international trade fairs and events. Feedback from distributors ('they are the most in touch with the markets you know' Director) urged the team to address a younger market, make it more child-centered and to have a younger main character. Feedback from one international broadcaster showed that some elements were suitable for their audiences and age demographics

[17] The BBC is one of the largest public service broadcaster in the world. 'CBeebies is the BBC's offering for young children …to educate and entertain our youngest audiences. We produce a mixed-genre portfolio of pre-school and early-school content encouraging learning through play for both girls and boys aged six years and under ...' Children's television production is a core value of PSB. See http://www.bbc.co.uk/cbeebies/grownups/about/cbeebies.shtml

wile others were not. The company met two people from CBeebies and their boss, the Head of Children's BBC. The BBC at this stage said they loved the look of it but it was too old for CBeebies which has a 4-7 years of age demographic.

The company undertook some small scale testing of ideas on children in Irish schools. However, during the pre-production stage, the knowledge of the audience is largely mediated through the client broadcasters and distributor/co-producer rather than gathered directly from the audience. The show had to conform to internal BBC house rules. Scripts and the animatic have to be approved by the BBC and thus go through periodic quality controls. Both RTE and the BBC have a 'public service' charter and thus the educational and science element of the show fits their mandate.[18]

C6.6 INSTITUTIONAL CONTEXT

C6.6.1 Associational Networks

KDub was incorporated in 2001 by three friends who had been at college in Ballyfermot together where they had studied animation and where they had later worked as part time lecturers. Only one of the original three is still in the company although the two directors and the art director have all attended Ballyfermot. The animation courses in this college were established in the 1980s with strong links to ex-Disney staff in the Irish based companies Sullivan Bluth and Murakami Wolf. The core strength of the courses has been their focus on traditional/classical animation skills rather than a focus on 3D and digital animation. KDub does however not maintain ongoing links with universities or colleges although there is clearly a sense of collegiality since the core of the team all attended the same college and were all trained in the same way.

Institutions such as the Irish Film Board (development grant) and the Broadcasting Commission of Ireland (Sound and Vision fund) and, indeed the Department of Finance (Section 481 Tax scheme) are of crucial importance to the development of the project.

At the start of the innovation trajectory, although they knew most of the names of relevant individuals and companies, the young company was still relatively weakly networked in the national and international animation scene. However, through visiting the annual international professional market events like MIFA, MIP TV and Kid Screen, organized by the international organizations, the company rapidly expanded its network of contacts, both international and national (e.g. with the national broadcaster)

The main artist is a member of the Irish Guild of Illustrators which he meets informally once a year. The company is represented on the *AnimationIreland* web-site managed by Enterprise Ireland, the national enterprise promotion agency. There are currently 12 companies listed on the *Animation Ireland* site. Enterprise Ireland has also supported travel to international professional events although it seems to focus

[18] The BBC is one of the largest public service broadcaster in the world. 'CBeebies is the BBC's offering for young children …to educate and entertain our youngest audiences. We produce a mixed-genre portfolio of pre-school and early-school content encouraging learning through play for both girls and boys aged six years and under ...' Children's television production is a core value of PSB. See http://www.bbc.co.uk/cbeebies/grownups/about/cbeebies.shtml

on the US events. This and the Irish animation blog *http://www.scamp.ie,* which is also frequented by KDub staff, are potential sources of local buzz

C6.6.2 Forms of Regulation

To an extent the content of the series is indirectly regulated by the fact that the client broadcasters experience a level of government and self-regulation. Both RTE and the BBC have a 'public service' charter. The educational and science element of the show fits their mandate. In addition, public broadcasters are concerned with how the content may influence role models and imitation behavior (see also footnote under section on type of user markets).

C6.6.3 Finance

Although the innovation trajectory of developing the animated television series was relatively short the investments of €5m are too sizeable for small animation companies to go it alone. Even the relatively small amount of finance required for the initial stages of development was too great for KDub. Therefore public funding and support from the public service broadcaster has been key to getting this and other projects into production. After this, the size of the Irish market and the structure of funding from some agencies means that company needs considerably investment from overseas to get to production. This generally includes a large foreign broadcaster or distribution company with the financial cloud to commission/finance projects and provide advance payments

In the case of the innovation under discussion, securing full development funding required the team to develop a full animated series specification book (also called a bible) and a pilot. About €40,000 is needed to produce these. The Irish Film Board Funding was crucial since it allowed the company to develop a 1-minute pilot and associated promotional materials for presentation at the international trade fairs. The company also got funding from Enterprise Ireland, the national enterprise development agency, to attend an major international trade fair.

RTE, the Irish public broadcaster came on board and gave a guarantee to screen the project (pre-sales) and a €50,000 advance payment. This was sufficient to secure development funding of up to 10.4% of development costs (producer equity) under the newly developed 'Sound and Vision' fund from the Broadcasting Commission of Ireland. This fund was set up to fund 'public service broadcasting' related projects and all terrestrial broadcasting companies could apply for funding which comes from the license fee. The BCI were keen to address the fact that the majority of animation shown on RTE was bought in from the United States. The BBC Worldwide signed up as a distributor (percentage funding). Another important element of the fiscal/financial puzzle was securing section 481 tax credit status in Ireland to get tax back on the production. The Canadian co-producer provided further funding in the form of labour credits in Canada for creating employment there. Each of the funding schemes had different rules and regulations; some were loans, some equity funding.

A second serried of 32 X 11 minute episodes is envisaged for which a further €1m would be needed. Some of this may be financed out of the revenue from the first series as well as merchandising and ancillary rights deals. In February 2009 company staff attended Kidscreen in New York in search of these additional deals.

13 BIBLIOGRAPHY

Abbott, A. (1988) *The System of Professions.* Chicago: University of Chicago Press

Allen, T. and S. Cooney (1974) The Technological Gatekeeper and Policies for National and International Transfer of Information. *R&D Management* 5, 1.

Amin, A. and P. Cohendet (2004) *Architectures of Knowledge* Oxford: Oxford University Press.

Arundel, A. Beuzekom, B. van and Gillespie I. (2007) Defining Biotechnology Carefully, *Trends in Biotechnology*, 25(8), pp. 331-332.

Asheim, B. and Gertler, M. (2005) The Geography of Innovation. In: J. Fagerberg, D. Mowery and R. Nelson, *The Oxford Handbook of Innovation*. Oxford: Oxford University Press.

Asheim, B., Vang-Lauridsen, J. and Coenen, L. (2006) Face-to-Face, Buzz and Knowledge Bases: Socio-Spatial Implications for Learning, Innovation and Innovation Policy, *Environment and Planning C.*

Asheim, B., Coenen, L. and Vang, J. (2007), Face-t-Face, Buzz and Knowledge Bases: Socio-spatial implications for Learning, *Environment and Planning* C 25(5), pp. 655-670.

Arita, T. and McCann, P. (2000) Industrial Alliances and Firm Location Behaviour: Some Evidence from the US Semiconductor Industry. *Applied Economics* 32, pp. 1391-1403.

Asheim, B., R. Boschma and Cooke, P. (2007) *Constructing regional advantage: platform policy based on related variety and differentiated knowledge bases*. Utrecht University Working Paper.

Baron, J., M. D. Burton and M. Hannan. (1996) "The road taken: origins and early evolution of employment systems in emerging companies" *Industrial and Corporate Change* 5, 2, 239-275.

Block, F. (2008) "Swimming against the current: The rise of a hidden developmental state in the United States" *Politics and Society* 36: 169-206.

Block, Fred and Matthew R. Keller (2008) Where do Innovations Come From? Transformations in the U.S. National Innovation System 1970-2006. Report published by *The Information Technology and Innovation Foundation*. Available at http://www.itif.org/index.php?id=158.

Boschma, R. (2005) Proximity and Innovation: A Critical Assessment. *Regional Studies* 39, pp. 61-74.

Bruland, K. and Mowery, D. (2005) Innovation Through Time. In: J. Fagerberg, D. Mowery and R. Nelson, *The Oxford Handbook of Innovation*. Oxford: Oxford University Press, pp. 349-380.

Chesbrough (2003) *Open Innovation*, Boston: Harvard Business School Press

Coenen, L., Moodysson, J., Ryan, C., Asheim, B. and Phillips, P. (2006) "Comparing a Pharmaceutical and an Agro-food Biorgeion: On the Importance of Knowledge bases for Socio-spatial Patterns of Innovation". *Industry and Innovation*, 13(4), pp 393-414.

Egeraat, C. van and Jacobson, D. (2006) The Geography of Linkages in the Irish and Scottish Computer Hardware Industry: the Role of Information Exchange, *Journal of Economic and Social Geography*, 97(4), pp. 45-18.

Forfás (2002) A Strategy for the Digital Content Industry in Ireland. Dublin: Forfás.

Forfás (2006) Future Skills Requirements of the International Digital Media Industry: Implications for Ireland Report. Dublin: Forfás.

Forfás: Dublin and The Digital Hub (2007). *Development Plan. International Digital Enterprise Area, Dublin*. Dublin: Forfas.

Gertler, M. (2008) Buzz without being there? Communities of Practice in Context. In: Amin, A and Roberts, J (eds.), *Community, Economic Creativity and Organisation.* Oxford: Oxford University Press, (forthcoming).

Gertler and Wolfe (2006) Spaces of Knowledge Flow: Clusters in a Global Context. In: Asheim, B., Cooke, P., and Martin, R., *Clusters and Regional Development: Critical Reflections and Explorations*. London: Routledge, pp. 218-236.

Girard, M. and D. Stark (2002) "Distributing Intelligence and Organizing Diversity in New Media Projects" *Environment and Planning A*, vol. 34, no 11, November 2002, pp. 1927-1949.

Haas, P. (1992) Introduction: Epistemic communities and International Policy Co-ordination. *International Organisation*, 46(1), pp. 1-35.

Hamel, J. (1993) *Case Study Methods.* Newbury Park: Sage.

Hollingsworth, J.R., P. Schmitter, W. Streeck, eds. (1994) *Governing Capitalist Economies: Performance and Control of Economic Sectors* Oxford: Oxford University Press.

Kim, L. and R. Nelson, (2000) *Technology, Learning and Innovation: Experiences of Newly Industrialising Economies* Cambridge: Cambridge University Press.

Kitschelt, H. 1991. "Industrial governance structures, innovation strategies and the case of Japan: sectoral or cross-national comparative analysis?" *International Organisation* 45, 4, 453-493.

InterTradeIreland (2003) *Mapping the Bio-Island*, Newry: InterTradeIreland.

Kerr, A. (2007) From Boston to Berlin – Creativity and Digital Media Industries in the Celtic Tiger. My Creativity Reader: A Critique of Creative Industries. G. Lovink and N. Rossiter. Amsterdam: Institute of Network Cultures.

Lave, J. and Wenger, E. (1991) *Situated Learning: Legitimate Peripheral Participation*, New York, Cambridge University Press.

Lazonick, W. (1991) *Business Organisation and the Myth of the Market Economy*, Cambridge: Cambridge University Press.

Lazonick, W. and Tulum, O. (2008) US Biopharmaceutical Finance and the Sustainability of the Biotech Boom, paper presented at the *25th Celebration Conference 2008 on Entrepreneurship and Innovation – Organisations, Institutions, Systems and Regions*, Copenhagen, CBS, Denmark, June 17-20, 2008.

Lester, R and M. Piore (2006) *Innovation* Cambridge, MA: Harvard University Press.

Lievrouw, L. A. and S. Livingstone (2006) Introduction to the Updated Student Edition. Handbook of New Media. L. A. Lievrouw and S. Livingstone. London: Sage Publications: pp. 1-15

.

Lorenz, E and B. Lundvall (2006) *How Europe's Economies Learn: Coordinating Competing Models*, Oxford: Oxford University Press

Lorenz, E. and Valeyre, A. (2006) Organizational forms and innovation performance: A comparison of the EU15, in Lorenz, E. and Lundvall, B.-Å. (eds.), *How Europe's Economies Learn*, Oxford: Oxford University Press, pp. 140-160.

Lundvall, B. (1992) *National Innovation Systems: Towards a Theory of Innovation and Interactive Learning*, London: Pinter.

Lundvall, BA, B Johnson, ES Andersen, B Dalum, (2002) "National systems of production, innovation and competence building" *Research Policy* 31, 2, 213-231

Nachira, F., Nicolai, A., Dini, P., Le Louarn, M. and Rivera, L. (2007) *Digital Business Ecosystems*, Luxembourg: Office of the Official Publications of the European Communities.

Malmberg, A. and Maskell, P. (2002) The Elusive Concept of Localization Economies: Towards a Knowledge-Based Theory of Spatial Clustering. *Environment and Planning, A* 34, pp. 429-449.

MCKinnon, A. (1997) Logistics, Peripherality and Manufacturing Competitiveness. *In*: B. FYNES and S. ENNIS, eds., *Competing from the Periphery: Core Issues in International Business*, pp. 335-369. Dublin: Oak Tree Press.

McNaboe, J. (2005) *Skill Requirements of the Digital Content Industry in Ireland*. Dublin: FAS, STem, Dublin City University, The Expert Group on Future Skills Needs.

Malerba, F. (2003) “Sectoral Systems: How and Why Innovation Differs Across Sectors” in J.Fagerberg et al *Handbook of Innovation*.

Millar, H. (200), Biotech’s Defining Moments, *Trends in Biotechnology*, 25 (2), pp. 56-59.

Moodysson, J. (2007), *Sites and Modes of Knowledge Creation: on the Spatial Organisation of Biotechnology Innovation*, Lund: Lund University.

Moodysson, J. (2008), Principles and Practices of Knowledge Creation: On the Organization of “Buzz” and “Pipelines” in Life Science Communities, *Economic Geography*, 84(4), pp. 449-470.

Moodysson, J., Coenen, L. and Asheim, B. (2008) Explaining Spatial Patterns of Innovation: Analytical and Synthetic Modes of Knowledge Creation in the Medicon Valley Life Science Cluster, *Environment and Planning A*, Vol. 40, pp. 1040-1056

Mowery, D. 2009. Plus Ca Change: Industrial R&D in the Third Industrial Revolution *Industrial and Corporate Change* 18, 1, pp. 1-50.

Nunan, D. (1992) *Research Methods in Language Learning.*: CUP.

Oerlemans, L. and Meeus, M. (2005) Do Organisational and Spatial Proximity Impact on Firm Performance? *Regional Studies* 39, pp. 89-104.

Oakey, R. (1995) *High Technology New Firms: Variable Barriers to Growth.*

Ó Riain, S. (2004). *The Politics of High Tech Growth* Cambridge: Cambridge University Press.

Powell, W. et al. (2005) “Network Dynamics and Field Evolution: The Growth of Interorganizational Collaboration in the Life Sciences” *American Journal of Sociology* 110: 1132-1205.

Pavitt, K. (2006) Innovation Process, in J. Fagerberg, D Mowery and R. Nelson (eds.), The Oxford Handbook of Innovation, Oxford: Oxford University Press.

Saxenian, A. (1994) *Regional Advantage:Culture and Competition in Silicon Valley and Route 128,* Cambridge, MA: Harvard University Press.

Storper, M. (1997) *The Regional World: Territorial Development in a Global Economy*. London: Guilford.

Storper, M. and Venables, A. (2004), Buzz: Face-to-Face Contact and the Urban Economy, *Journal of Economic Geography,* 4, pp. 351-370.

Sturgeon, T. (2002) Modular Production Networks: A New American Model of Industrial Organization. *Industrial and Corporate Change* 11, pp. 451–496.

Torre, A. and Gilly, J. (2000) On the Analytical Dimension of Proximity Dynamics, *Regional Studies*, 34, 169-180.

Torre, A. & A. Rallet (2005) Proximity and Localization. *Regional Studies* 39, pp. 47–59.

Yin, R. (1993) *Applications of Case Study Research.* Newbury Park: Sage.

Yin, R. (2003) *Case Study Research: Design and Methods*, Thousand Oaks: Sage Publications.