KNOWLEDGE GOVERNANCE FOR OPEN INNOVATION : EVIDENCE FROM AN EU R&D COLLABORATION

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Introduction

This chapter highlights a particularly challenging arena for knowledge governance, by focussing on the governance issues associated with large-scale programmes of what has been termed 'open innovation'. As outlined in more detail below, open innovation - also sometimes labelled synonymously as 'networked' or 'distributed' innovation - is an increasingly important component of the wider patterns of innovation in advanced economies. It can be seen in large part as a response to firms' increasing needs to draw on external sources of knowledge in order to remain competitive in a global economy.

Issues of knowledge governance are at the heart of open innovation inasmuch as such innovation is acutely dependent on the organization of knowledge flows between and within firms. The ability of firms to acquire externally-sourced knowledge has been a major subject of academic debate since the pioneering work of Cohen and Levinthal on 'absorptive capacity', and Von Hippel's studies of user-driven innovation (Cohen and Levinthal 1990; von Hippel 1988). However, the distinctive challenges posed by an avowedly open approach to innovation processes are still being digested by researchers. These challenges go some way beyond the problem of absorbing knowledge. According to its proponents, open innovation involves a qualitative shift in the way the firm creates, exploits and organizes knowledge. This has wide-ranging implications for the way the focal firm manages itself and its knowledge-base. At the very least, open innovation implies a reduced dependence on internal R&D functions and a greater willingness to trade knowledge with external collaborators. More broadly, though, the serious pursuit of open

innovation is likely to extend to radical changes in the structure and management practices of the firm to foster greater interactivity with the expanding ecology of knowledge providers.

It is not within the scope of this paper to address all of the many challenges which open innovation creates for established governance arrangements. Rather, our aim is to provide an initial exploration of some of these challenges by analysing a case-study of a more open form of innovation. This is an important but also especially complex case because it has to do with MOZART[1], one of the major collaborative research programmes sponsored by the European Union (EU). This programme represents a unique institutional response to the needs of the aerospace industry in Europe, reflecting not only the diverse needs of the participating companies but also the strategic interests formulated by the EU as a political body. As such it raises the challenges of knowledge governance to a new level, since it encompasses not only questions of effective governance for an innovation process, and the inter-firm collaboration underpinning it, but also the wider challenge of linking private enterprise with the strategic objectives of multi-state bodies.

The remainder of this chapter then proceeds as follows. We begin, in the following section, by identifying the major governance challenges arising from open innovation. This is followed by our case-study of the MOZART programme, and subsequently our analysis of that case in terms of the governance challenges highlighted previously. The chapter concludes with a brief discussion of the implications of the case and an outline of areas for further research in the future.

Context for the study

At least since the 1980's (Pisano 2006), there has been a trend for firms to pursue innovation through collaborations reaching beyond firm boundaries. Such collaborations range from greater reliance on external networks for accessing knowledge, through to formal alliances and joint ventures. One of the principal motives for this trend is the need to access and integrate those distributed sources of knowledge which provide the raw material for innovation processes (Gulati and Gargiulo 1999). Most recently this increasing reliance on external collaborations has been highlighted by Chesbrough's notion of 'open innovation'. This is said to describe a paradigm shift in how companies commercialize industrial knowledge (Chesbrough 2003), and it is contrasted with the 'closed innovation' model in which companies are

[1] MOZART is a pseudonym, adopted here to protect confidentiality.

largely self-reliant in their innovation efforts. Chesbrough argues that a number of factors have undermined the logic of closed Innovation. These include; the dispersion of scientific and technological knowledge due to the mobility of highly skilled workers; the growing presence of venture capital (VC) in funding innovation; the increasing role of user groups; the role of universities and technological service centers; and the shortening of technology lifecycles. These factors are seen as encouraging open innovation by placing much greater emphasis on the acquisition of external knowledge, a greater role for user groups, and a more collaborative approach to the management of intellectual property.

As Chesbrough's account indicates, the increasing importance of more open forms of innovation encompasses a wide variety of interactions between firms, suppliers, customers and users. The particular focus of our study, however, is upon the development of more open approaches to the R&D component of the innovation process. The drivers for such R&D-centred collaborations have been widely discussed in the literature (Hagedoorn 2002). They are seen as enabling the exchange of knowledge and competencies (Borgatti and Cross 2003), so as to accelerate innovation processes, reap economies of scale in R&D, share risks and costs (Nakamura, Vertinsky and Zietsma 1997), and enhance access to the market (Acha and Cusmano 2005). Such collaborations have been variously described under the headings of R&D consortia (Nakamura, Vertinsky and Zietsma 1997), R&D alliances (Oxley and Sampson 2004), R&D joint ventures (equity and non equity), communities of creation (Sawhney and Prandelli 2000), R&D co-operation (Acha and Cusmano 2005) and R&D partnerships (Hagedoorn 2002).

Despite the growth in the number of R&D collaborations and the interest they have generated, they are also seen as presenting significant governance challenges (Dyer and Nobeoka 2000; Simon and Kotler 2003). Many of these challenges centre on the fundamental transactional problems affecting any traffic in knowledge between parties, as highlighted by Williamson and other economists. These challenges include, for example, the problem of information asymmetry between parties, the dilemma of disclosure involved in valuing knowledge, and the risk of appropriation (Teece 1986). However, as described in more detail below, these transactional problems also need to be placed in the wider governance context where the forms of knowledge involved, and the evolving relationships between parties may exert a crucial influence on actual outcomes.

It is certainly true that in practical terms, the failure to overcome these governance challenges has resulted in many collaborations falling short of expectations (Bleeke

and Ernst 1993; Ritter and Gemünden 2003). This suggests that the advantages which open innovation creates in relation to accessing external sources of knowledge also need to be balanced against the difficulties of collaboration in circumstances where exchanges are subject to neither the explicit criteria of the market, nor the authority structure of the hierarchy. As Powell points out, in such circumstances; 'Collaboration can be fraught with other risks. Parties may bring hidden agendas to the venture. There is an ever-present threat that one party will capture the lion's share of the benefits, or defect with the other party's knowledge and expertise' (Powell 1990: 318). These governance challenges create some profound dilemmas for firms, who, as Oxley and Sampson (2004) put it; 'must…find the right balance between maintaining open knowledge exchange to further the technological development goals of the alliance, and controlling knowledge flows to avoid unintended leakage of valuable technology.' (p. 723).

In the subsequent section, we aim to outline a theoretical framework capable of addressing the governance challenges posed by open innovation, and their associated dilemmas of openness and closure.

Theory review and development

The framework outlined here is based on a review of the wide and diverse literature pertaining to open innovation. We have viewed this literature through the lens of 'knowledge governance' which we interpret broadly in terms of a concern with the interplay between knowledge processes (Argote 1999) and the deployment of governance mechanisms (Foss 2007), within a context of exchange hazards created by appropriability risk and opportunism. Applying this approach to open innovation highlights, first, the distinctive knowledge processes associated with such innovation. One strand of the literature here has focussed on the transformations of knowledge encompassed by the innovation process. This strand has been highly influenced by Nonaka's account of a 'spiral of knowledge creation'. Thus, Nonaka describes the innovation process in terms of four stages of knowledge creation which he terms 'internalization' (explicit to tacit knowledge), 'socialization' (tacit to tacit knowledge), 'externalization' (tacit to explicit), and 'combination' (explicit to explicit) (Nonaka 1994). Although subsequent work has tended to focus on the conversion of tacit to explicit knowledge as a key feature of this account, an equally important contribution is the way Nonaka highlights the episodic character of the innovation process,

showing the transformation of knowledge into different intermediate states prior to its final realization as an innovative offering in the marketplace.

While the transformation of knowledge is one important dimension of open innovation, reliance on wider external networks of collaborators also places an emphasis on the need to integrate knowledge across organizational boundaries. Although the concept of knowledge integration is sometimes used broadly to denote the coordination of different knowledge-based activities (Grant 1996), in the context of innovation it is seen as closely linked to the quality of relationships between individuals and groups. One study, for instance, concludes that 'while the factual content of information is important to knowledge integration . . . the way in which that knowledge is accessed and the point of view from which it is considered . . . also influences how individual knowledge is combined.' (Okhuysen and Eisenhardt 2002: 384). Relationships are important here, because as Carlile puts it, knowledge integration involves overcoming the 'knowledge boundaries' between groups (Carlile 2002). Overcoming such boundaries is critical to enabling the transformations in knowledge required by the innovation process.

Given these characteristic features of open innovation – the dynamic nature of the process, combined with the importance of the relationships between groups – it is not surprising to discover widespread agreement that governance structures or organizational forms play a crucial role in enabling knowledge sharing and protection within inter-organizational collaborations (Kale, Singh, and Perlmutter 2000; Pisano 1990). Where there is much less agreement, however, is on the role played by specific governance mechanisms in different settings. Here, we find studies diverging between those which emphasize formal mechanisms of governance, on one hand, and those emphasizing what are termed 'relational' mechanisms on the other. Formal mechanisms here refer to defined organizational and legal features such as corporate ownership, structural design and legally-binding contracts. Joint ventures and strategic alliances, for instance, represent different formal mechanisms of governance. Relational mechanisms, however, refer to forms of governance which rely upon the social ties created by prior experience and trust between partners.

Despite the tendency to view them as alternatives or substitutes, there is increasing evidence to suggest that formal and relational mechanisms operate in a complementary fashion (Poppo and Zenger 2002). For example studies of formal organizational networks frequently depict them as being reinforced by informal, or

inter-personal, networks (Grandori and Soda 1995; Kreiner and Schultz 1993). Indeed, Gulati and Singh (1998) concluded that the social networks underpinning strategic alliances not only influenced the creation of new ties but also affected the design, evolutionary path, and ultimate success of such alliances.

Existing work has identified a number of possible interaction effects between formal and relational governance mechanisms (Ouchi 1980). Relational mechanisms are identified in a number of instances as exerting a moderating effect upon the scope and complexity of formal mechanisms. Thus, the relational influence of prior ties on partner selection may affect the use of formal mechanisms for inter-organizational collaboration (Gulati 1995). Linked to this is the idea that relational governance moderates formal governance through the learning process created by repeated interactions between partners (Uzzi 1997). This is seen as providing greater information on the partner's intentions and competence (Gulati and Gargiulo 1999).

Others see the interaction between formal and relational mechanisms more in terms of one substituting for the other. Thus some writers argue that trust between partners reduces the need for formal governance mechanisms since social ties help to reduce goal conflict and weaken the risk of opportunistic behaviour (Dekker 2004; Poppo and Zenger 2002). This substitution effect, though positive in terms of partnership costs, may not always be functional for the organizations concerned. As recent studies, have suggested, over-reliance on socially embedded relationships as a proxy for formal governance may also be detrimental to inter-organizational collaboration. Thus, studies have found that over-reliance on inter-personal trust may undermine effective partner selection (Newell and Swan 2000), and that embedded social networks may limit the exchange of knowledge and information (Edelman *et al*. 2004).

Another area where existing studies diverge is in the way they characterise the object of governance mechanisms (Dekker 2007). A great number of studies highlight the importance of such mechanisms in relation to exchange hazards (Geyskens, Steenkamp, and Kumar 2006). Here, the extent and complexity of governance – that is, the organizational elaboration and effort involved (Gulati and Singh 1998) - is related to the severity of the exchange hazards involved in a particular inter-organizational collaboration. Others, however, link to the wider literature on organization design by focussing on the role of governance as a means of coordinating interdependent tasks (Grant 1996; Gulati and Singh 1998; Thompson 1967). The emphasis in these studies is on the implications of complex and distributed divisions of knowledge and labour for task coordination (Grant 1996). A

higher level of task interdependence is seen as associated with more complex governance structures (Gulati and Singh 1998).

Again, as with formal and relational mechanisms, we note that exchange hazards and coordination requirements frequently interact. From the existing literature, there seems to be a strong reinforcing effect between the level of coordination requirements and the level of exchange hazards. As Oxley and Sampson put it; 'The more extensive, interdependent, complex, and uncertain are the activities performed in the alliance, the greater is the potential risk of opportunism. This is because the extent of coordination and more intimate face-to-face contact necessary to achieve success increases along these dimensions . . . and uncertainty raises the costs of monitoring and assessing partner behavior' (Oxley and Sampson 2004: 726) . This uncertainty has implications also for appropriability, since greater interdependence makes it more difficult to identify and enforce claims to the knowledge produced through inter-organizational collaboration.

Developing propositions

The above discussion of the existing literature in this field highlights features of the knowledge processes, inter-firm relationships and governance mechanisms encompassed by open innovation. We have noted that open innovation creates distinctive challenges for governance, due to the transformative and episodic nature of the innovation process itself, combined with the need to integrate knowledge across organizational boundaries. The aim of this section is to further extend this account by focussing more closely upon the interplay between knowledge process and governance mechanisms. This leads us to outline some indicative propositions on that interplay, which will subsequently inform our case analysis and discussion.

One important aspect of the knowledge process for open innovation is the forms of knowledge involved. As noted previously, the work of Nonaka highlighted the importance of tacit knowledge within innovation processes. The problems of contracting and monitoring such knowledge (as compared to explicit knowledge), and its asset specificity, are generally seen as an argument for hierarchical or joint venture-based forms of governance to minimize the problem of opportunism, free-riding and misappropriation (Oxley and Sampson 2004; Williamson 1985). In addition, (but often related to the tacit dimension of knowledge) is its 'system embeddedness'. This is contrasted with modularity, where knowledge can be acquired and transferred in a more discrete way (Winter 1987). Knowledge may be

modularised by specialism or episodically, as with pre-competitive R&D collaboration (Oxley and Sampson 2004; Sanchez and Heene 1997). Greater modularity can be seen as reducing the need for complex forms of governance, and as enabling more transparent and arms-length relationships between the partners involved.

Consideration of these governance implications of tacitness and system embeddedness for open innovation leads to the following proposition: *open innovation will occur most readily when it involves the integration of more modular and explicit forms of knowledge*. Conversely, *dependence on tacit and embedded forms of knowledge will be more difficult to accommodate within an open innovation process due to the complexity of governance mechanisms required*.

Further propositions can be derived when we consider the implications of knowledge form for relational mechanisms of governance. Thus interpersonal networks, involving deep, trust-based relationships have been seen as more appropriate for the integration of tacit forms of knowledge (Oliver and Liebeskind 1998). Conversely, inter and intra-organizational networks based on weak/shallow ties are found to be more effective for the integration of explicit forms of knowledge (Hansen 1999). This leads to the proposition that: *where open innovation processes do require the integration of tacit knowledge, this will only be possible through relational mechanisms involving strong ties between network participants*.

In turn, we also need to address the temporal and episodic nature of the innovation process and its implications for governance. In much of the existing literature, governance mechanisms are viewed as a function of the characteristics of the knowledge process or inter-organizational relationships. However, this emphasis on the structural solutions to the governance challenge may also be neglecting the recursive relationships that operate between knowledge process, inter-firm relationships and governance mechanisms. Such recursiveness is an important issue for innovation processes which, as we have noted, unfold episodically over time. This suggests that governance mechanisms may well react back upon the relationships between partners or the scope of knowledge processes - that is, the extent and forms of knowledge which are shared under a particular form of governance. This may occur, for instance, through the relationship building effects of particular governance choices. Thus, Oxley and Sampson found that in some instances ‘the choice of an equity joint venture encourages alliance partners to engage in joint activities that go beyond ‘pure’ R&D’ (Oxley and Sampson 2004: 724). Equally, governance arrangements may also have relationship-inhibiting or even damaging effects, as where formal governance mechanisms are taken to signal distrust between parties

(Das and Teng 1998). Similar considerations may arguably apply also to the influence of governance mechanisms upon knowledge processes. De-limiting the scope of joint activities, for instance, is likely to emphasize the modularization of knowledge within the innovation process (Brusoni, Prencipe, and Pavitt 2001).

Summarizing the implications of these recursive and unfolding aspects of the innovation process suggests the following overarching proposition: *the governance mechanisms adopted for open innovation are likely to evolve over time, with some path dependency in the course of their evolution – i.e. initial governance conditions are likely to exert an enduring influence*. Specifying the possible governance paths involved is inherently problematic given the above comments. However, two contrasting propositions help to highlight the possible variance. First, *the initial adoption of formal mechanisms with positive relational effects, such as the joint venture form, is likely to encourage stronger ties and hence greater ability to integrate tacit and embedded forms of knowledge*. Second, *the adoption of formal mechanisms with negative relational effects (as with legalistic forms of contract), is likely to encourage weaker ties between firms, and hence greater ability to integrate explicit and modularized forms of knowledge*.

Finally, one issue which we have not focussed on explicitly in our review of the literature is the appropriability of the knowledge created within the innovation process. This may clearly be an important consideration, and, as noted above, is linked to other issues such as the degree of task interdependence within the knowledge process, and the embeddedness of relationships between firms. What makes it difficult to specify this feature any further, however, is the importance of the wider appropriability regime as an exogenous influence on open innovation. Thus, we can note that where the appropriation regime is weak, there is a strong likelihood that innovators would likely exploit innovation internally, either by using internal resources or creating a spin-off, rather than through external means like patents and licences (Shane 2002). However, while the conventional view has suggested that 'strong' appropriation regimes are the most conducive to inter-organizational collaboration, Pisano notes that there may also be occasions on which strong intellectual property protection may not be most advantageous to innovating firms (Pisano 2006). As he notes, weak regimes for the R&D component of open innovation may sometimes be preferred even by established firms because they provide a more effective way of leveraging their advantages in complementary capabilities such as marketing and manufacturing.

In Figure 1, we have sought to bring together and summarise these interactions as a propositional framework to be applied to our empirical study. In the next section, we will provide a brief description of our case-study of the MOZART programme, allowing us to ground our subsequent analysis and discussion in the comparison between the propositional framework outlined here and the actual conduct of this large-scale, highly complex example of open innovation.

MOZART and ITNET[2]: A Case Study of R&D collaboration in the aerospace sector

This case study is provided here primarily as a means of illuminating the theoretical propositions outlined above. Data for the case was elicited through multiple means, including participant observation, hands-on involvement in project delivery, together with interviews with some key actors in the programme, and analysis of documents.

MOZART – An Overview

To explore our propositions about knowledge governance within an open innovation context, we turn now to our case-study. MOZART is one of the FP6 research projects of the European Commission. MOZART was officially launched in January 2004 to run till December 2007. However, it has a longer 'informal' lifespan dating back to the days of a previous FP5 project – i.e. the ENHANCE programme. The MOZART integrated research and technology project, which is coordinated by Airbus, was set up by the European Union with a budget of around 74 million euros, as one of its objectives to addressing its aerospace Vision 2020 objectives. To foster collaboration in the sector, the budget is shared between 63 companies and institutions that are co-operating in the programme.

MOZART can be seen as reflecting a distinctively European approach to open innovation, in that it involves the application of public funding to the development of a wide network of organizations. As we will describe in more detail below, this is an open approach to innovation only in the minimal sense that it involves multiple firms and a requirement to integrate multiple, distributed sources of knowledge. The relative openness of the inter-firm networks engaged by MOZART – that is, their

[2] As with MOZART, 'ITNET' is a pseudnym adopted to protect confidentiality.

willingness to access and share knowledge with outside groups - varied significantly over time and across different work packages.

The formal goal of MOZART is to achieve a 5% cost reduction in aircraft development and a 5% reduction in the development phase of a new aircraft design, combined with a contribution to a 30% reduction in the lead time and 50% reduction in development costs respectively for a new or derivative gas turbine. It is expected that MOZART will deliver a virtual product design and validation platform, based on a distributed concurrent engineering methodology supporting the virtual enterprise. The main result of MOZART will be an innovative Aeronautical Collaborative Design Environment and associated processes, models and methods. This environment, validated through concrete Use Cases (i.e. real life cases on industrial sites), will help to design an aircraft and its engines, providing virtual products to the aeronautics supply chain operating in an extended enterprise, which has all the requested functionality and components for each phase of the product-engineering life cycle. It is also expected that the new approach of working developed by MOZART would be made available to the aerospace supply chain via existing networks, information dissemination, training and technology transfer actions.

MOZART and the innovation process

The MOZART programme is based on a ‘concurrent engineering’ approach to innovation (Clark and Fujimoto 1991). Concurrent engineering (CE) is an engineering practice that came into prominence in the auto industry late 1980s in relation to the increasing competitiveness of the economic landscape. It was a radical break with the sequential engineering (over-the-wall approach) that had dominated new product introduction for decades. It was seen as a way to respond faster to market needs, reduce time to market and minimise cost. CE subsequently diffused into other sectors, including aerospace. One of the means of this diffusion was through recruitment of people with experience of CE in automotive in the mid 90s. Currently, CE is widely adopted in the aerospace sector as an important approach to open innovation.

One of the key characteristics of CE is its emphasis on collaboration and team work amongst stakeholders – especially in the design phase of new products. However, collaboration within and across firms brings with its challenges, which include difficulty in data exchange, knowledge boundaries, knowledge leakages, transaction costs and other governance and coordination problems. The practice of CE has been

sustained, however, despite these challenges as firms seek new ways of mitigating the challenges. An example of how CE is coping with these challenges is the use of information technology, and especially the Internet, to minimise knowledge leakages and reduce transaction costs through standardised security systems and web-based processes.

At a policy level, the MOZART programme was predicated on the EU's goal of pursuing "sustained competitiveness of the EU aerospace sector". This goal was manifest in different strategy and vision texts produced by the EU, as well as national governments (e.g. SBAC, UK) and aerospace firms (e.g. through MOZART vehicle). In addition, exploiting these new IT-based opportunities for CE was also in line with the EU's strategic objective of developing new ways of working in Europe based on opportunities offered by ICT: MOZART was funded 50% by the aerospace and 50% by ICT units of the European Commission. The overall rationale for the programme came from the policy-makers' belief that the aerospace sector needed to change its design and development practices as well as work more closely with its supply chain. Structural changes in the industry (e.g. privatisation) and the global economy had already ushered in outsourcing, which in turn necessitated migration of competences from OEMs to supply chains. Large companies had become focussed on their core competencies, becoming system integrators or builders, rather than manufacturers (Bhattacharya et al., 1995). Against this backdrop, collaborative approaches to innovation were trumpeted as a way to cope with the challenges of competition (mainly coming from the USA and lately Asia – Japan) and to retain the EU aerospace sector as the crown jewel of Europe's industrial base. It was also expected that developments in ICT could contribute significantly to achieving these changes in product design and development as well as enhancing supply chain relationships.

The aerospace sector has historically not been very enthusiastic about promoting collaborative work in new product development. One of the reasons for this could be the military antecedents of the sector which rather promoted an attitude of "keeping your cards close to your chest" and protecting national interests, which militated against collaborating and sharing expertise. The second reason is that the major OEMs (original equipment manufacturers) in the sector originally had all the required expertise in-house and did not see the need to collaborate. The preference for in-house development and the hoarding of knowledge persisted with some firms even as the MOZART programme was being developed. This clashed with the programme imperative to share knowledge within European networks. A good example of this

was the situation where one of the initial partners was forced to withdraw because other partners feared the results of Mozart would be applied outside the European networks through operations in North America.

MOZART governance structure

MOZART was deeply embedded in both formal and informal networks. The EU aerospace sector is a close-knit network of OEMs, 1st and 2nd tier suppliers and so on. However, the tentacles of these networks are not limited to Europe. For instance, a good number of the OEMs are multinational firms that have offices outside Europe. Given that the primary goal of MOZART was to enhance the EU aerospace expertise, the selection of project members reflects this intention. As a result, the network evolved mainly through informal networks or existing relationships, reflecting the existing structure of the EU aerospace sector.

Most of the members of the network were invited to join through prior working relationships with one another in the past or at the time of organising the network. A good number of them were involved in the FP5 project ENHANCE. In fact, the MOZART project was originally conceived as two separate projects – one focusing on engine design and development, led by Rolls Royce, and the other focusing on airframe design and development, led by Airbus. Both Rolls Royce and Airbus had their own networks. But because the projects were closely related, the European Commission decided to merge the two – in effect, a forced marriage – which meant that the two hitherto separate networks needed to fashion new ways of working together. The overlapping informal networks between engine manufacturers and airframe manufacturers helped to foster some links within the resulting network. For example, both Rolls Royce and Volvo Aero are first tier suppliers to Airbus, which required them to work closely with each other. This previous relationship helped in building a new network of partners through what could be termed ‘a cross-fertilisation of social capital’ amongst existing innovation networks.

Alongside the relational mechanisms based on prior experience, the development of MOZART also involved the development of some complex formal mechanisms of governance. In particular, the requirements from each partner and the anticipated working procedure of the network were explicitly specified in a detailed 200 page contract. This also requires each of the participating firms to declare and document, ab initio, the know-how and expertise they are bringing to the collaboration. Despite this level of bureaucratic detail, however, these contracts were not seriously applied

as mechanisms for the governance of inter-firm collaboration. They were rather artefacts designed to meet the requirements of the funding body. In terms of day-to-day activities, governance at the inter-firm level was much more reliant on the relational mechanisms created by trust and prior experience.

MOZART itself was divided into work packages according to areas of specialisation – i.e. engine, airframe, and information technology – with different firms acting as work package team leaders. Each of these work packages has its own selection and governance mechanisms. However, there were situations where participating firms straddled work packages. In such instances, the partners were bound by the governance mechanisms of each of the work packages they belonged to. This involved some adaptation of internal organizational practices to harmonise or cope with the demands of the various contracting regimes.

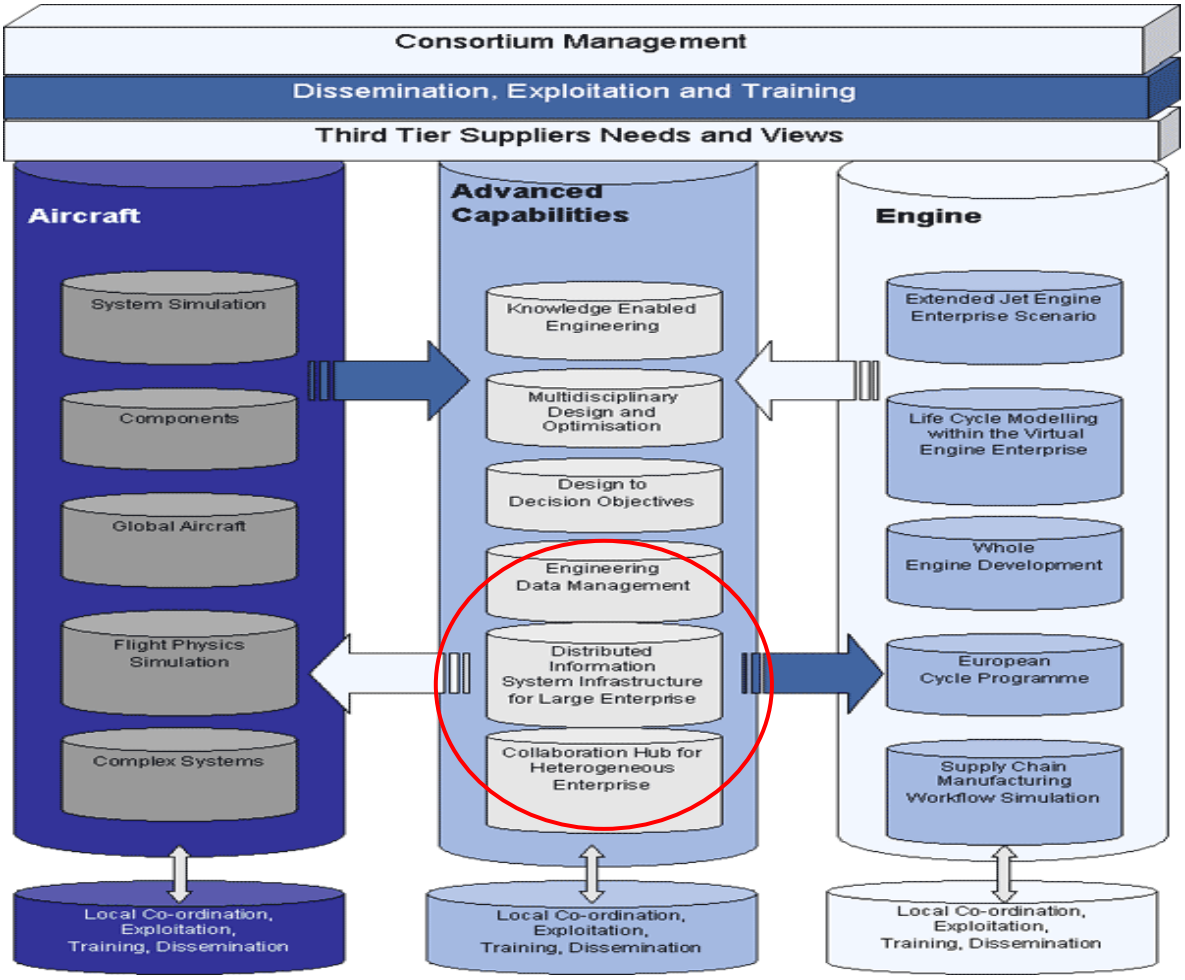
Overall, and in addition to the common contract, MOZART had a formal work breakdown structure as illustrated in Figure 2 below. The work packages decided for themselves on how and who to share their results with. In some cases, these work packages reflected pre-existing collaborations, while in some others, such as firms in the forced marriage network they did not.

This distribution of authority between programme and work packages was also linked to the fears amongst some firms that the MOZART network did not provide a reliable context to minimise knowledge spill-over. It could also have arisen from the fact that the different specialisations had different collaborative work cultures and histories. For instance, firms on the engine side of the programme were well versed in collaborating with each other. In contrast, the airframe side was heavily linked to defence and military interests that constrained collaboration.

A significant finding from the study, however, was the degree of variation which took place in the knowledge sharing and exploitation practices of these work groups over time. Some work groups started with the explicit intention of being open in terms of sharing knowledge with other groups within the wider Mozart network, only to adopt a more closed policy later. Some groups followed the opposite path. These variations in governance and policy reflected, in part, the shifting relationships between firms, within the MOZART network. In some instances, however, they reflected the transformative and episodic character of the early-stage innovation process itself. Thus some work groups shifted towards a closed network posture when they believed they had created original and valuable knowledge in their early-stage work, only to relax towards a more open stance when that work was re-assessed as having

little intellectual property potential. Again, other work groups followed the opposite trajectory. Both of these trajectories were facilitated by renegotiations of contracting regimes at the work package and project levels. The ITNET work package presented below offers a good case of a movement from closed to open innovation.

Figure 2: Work breakdown structure for the MOZART programme



ITNET work packages

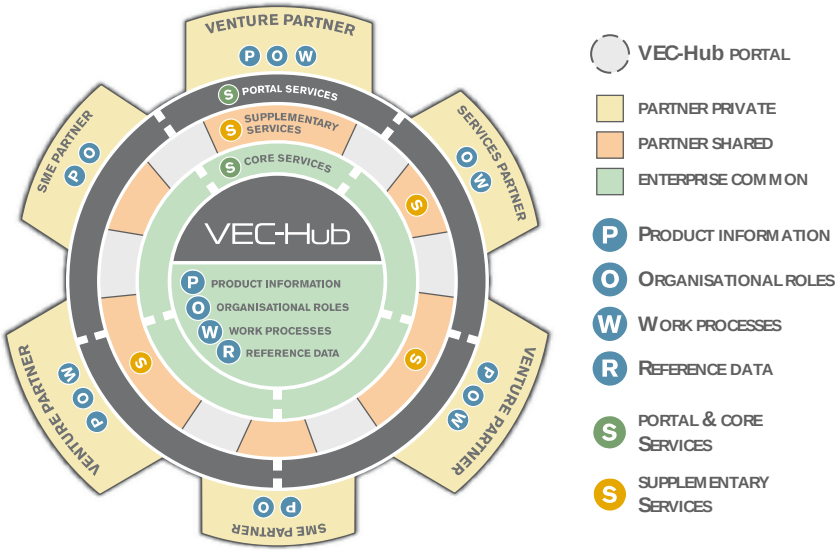
MOZART was made up of three core components – engine, airframe and information technology. The information technology part (called Advanced Capabilities) was there essentially as an enabler to both engine and airframe design and development. This element was advanced principally through the ITNET work packages (circled in Figure 2 above) which was given the responsibility of developing tools and

methodologies to enhance data interoperability via the web. It was the anticipated technology on which the virtual enterprise architecture would be built. The project was made up of information technologies companies that supplied to both the airframe and engine sides of the consortium. Their main role was to provide an enabling information technology infrastructure that would facilitate effective virtual new product development collaboration without compromising on intellectual property or company know-how.

Initially, one of these work packages (i.e. Collaboration Hub) started by agreeing to limit the exploitation of results of the research to work package members. This may have been because the firms in the information technology sub-group were not necessarily tied to the aerospace sector. They came with generic skills and expertise, and the technologies they developed could have had applications outside aerospace. Information from our interviews suggested that ITNET members did not wish to restrict themselves to aerospace intellectual property in the first instance, but rather wanted findings they could commercialise in the broader IT market. Given this, the work package members decided initially to limit its exploitation within familiar networks of information technology partners in the same sub-group, the broader formal contract governing MOZART notwithstanding.

Despite this initially closed and relatively marginal position, with the passage of time the ITNET work packages migrated from being a fringe player in the network to being a dominant one, at least in the sense that it became perceived as one of the key result providers (classed as one of the five “wonders” achieved by MOZART). This transition could be attributed to a number of things, including the pioneering role of the leader and his firm, but also a change in its governance structure towards an ‘open source’ model. To begin with the leader’s role, this individual was employed by the subsidiary of a major engine collaborator in the project. He was able to leverage his network influence and access to powerful resources (e.g. the influence of the engine side of his corporation in the MOZART network) to reposition the ITNET work package to the fore. The ITNET also built a network around itself by creating links to other work packages, which created interconnectedness to work packages within the other work packages (Engine and Aircraft) – see Figure 3. To do this, it had to position itself as a ’commonly available tool having no particular allegiance’, which could be of value to the different projects without threats.

Figure 3: ITNET interconnectedness with other work packages



This work package started canvassing for people in other work packages who championed their cause, through such means as training programmes, presentations at conferences and provision of e-learning demos. It also positioned itself as a solution that went beyond the current demands of the R&D network and sold its value post the duration of the research project. At the same time, it was involved in standardization of its content through such bodies as ISO14001 and other standardisation bodies. This gave the project a visibility that was quickly noticed by the consortium management.

A final strategy in this gaining of centre stage position and interconnectedness involved making the ITNET research outcomes accessible to others in order to maximise its usefulness and centrality. The ITNET thus became an open resource to members of MOZART. All its documents became available on the MOZART portal. Originally, the ITNET was meant to support only the integration of the engine and

airframe components of the MOZART project. It later positioned itself as a form of open-source in order to attract significant interest that could lead to possible standardisation of the hub both within and without MOZART. One could argue that with time, the ITNET learned to adapt to both the airframe and engine sides of the consortium and leveraged its expertise to gain a centrality that has made it indispensable in the programme. This indispensability also meant that the ITNET needed to shift from its original position of exploiting its results amongst its core members to an open-source approach within the broader governance of the MOZART R&D network.

Analysis and discussion

Before analysing what the MOZART case has to tell us about the relationships outlined in our theory framework, it is worth noting that one of the most striking features of this case is the sheer complexity of governance and the overall scale of transaction costs involved. Given the uncertain benefits of the R&D collaboration advanced here, as well as the difficulties of appropriation for quasi-public goods, it seems reasonable to argue that MOZART could only have been developed with the institutional and financial support of the EU and its member states. The involvement of the EU is not only important in providing the necessary resources for complex governance structures, but is also a major contributor to their complexity as the vertical relationship between the EU and the programme creates additional needs for coordination, oversight and transparency. The resulting complexity of the governance structure for MOZART also brings into sharp relief the crucial role which new internet-based technologies played in absorbing complexity and reducing transaction costs to a feasible level (Child and McGrath 2001). As was noted in the case, and as we will explore in more detail below, the influence of IT on governance, indeed its role as a mode of governance alongside organizational form (Weick 1990), was not only a feature of the programme as a whole, but was also important in shaping the paths taken by different work packages within that programme.

If the complex governance of MOZART reflects the potential impact of strategic state intervention when allied with new IT systems, we must not forget also that the overall scope of the programme was restricted to pre-competitive R&D, which arguably tells us something about the limits of what is achievable by such intervention. The willingness of companies to engage in collective programmes is obviously greater where such programmes are broadly aligned with their strategic objectives –

something which MOZART sought to achieve by linking EU interests to the goals of established EU-based firms – but also for arenas, such as pre-competitive R&D, which are not subject to the same risks of knowledge spillover and appropriability as would apply to later episodes of the innovation process.

These considerations may help to account for the relative complexity of governance in the MOZART case. This level of complexity would certainly caution against generalizing too far from this special case to other instances of open innovation. On the other hand, in many other respects the interactions between the members of the MOZART programme reflected many of the relationships which our theory framework derived from previous work in this field. To begin with the relationship between knowledge process and inter-firm relationships, we can readily see the implications of MOZART's emphasis on 'concurrent engineering' for the level of task interdependence within the knowledge process. Concurrent engineering specifies much higher levels of cross-functional interaction in developing new products. In other words, it creates a greater requirement for the integration of tacit and embedded forms of knowledge. This is difficult enough to achieve within the focal firm, but for open innovation it also involves overcoming inter-organizational boundaries. One consequence, as seen in the MOZART programme, seems to have been a reduced emphasis on the modularization of knowledge in favour of greater reliance on strong ties and the socially embedded relationships capable of supporting high levels of knowledge integration that continuously developed during the programme. In this sense, the importance of prior ties in the selection of partners seems not only to have mitigated against the risks of appropriation and opportunism, but also aided the level of knowledge integration required by this more interactive approach to innovation.

These factors also help to make sense of the important role which work packages played within the programme as a whole. Caught between the need to integrate knowledge across boundaries, yet alert to the exchange hazards thereof, companies were best able accommodate their concerns at the work package level of governance since the latter's domain scope fitted best both the required extent of knowledge integration and the pattern of prior network ties that would contain unwanted knowledge spillovers. Governance mechanisms at the programme level were more problematic from this point of view, because they were driven more by EU goals than by the dynamics of the open innovation process.

To turn now to the governance mechanisms developed within the MOZART programme, it is clear from the account above that these mechanisms had to

address the demands posed both by task coordination and by exchange hazards. Doing this involved fully exploiting the complementarity between relational and formal mechanisms. Thus, the detailed strictures of the 200-page formal contract were complemented by a selection of partners based to a large extent on prior ties (Dekker 2007). Similarly, as noted above, the scoping of collaborative activities was also carefully designed to meet the task coordination of the work packages while aligning with established networks within the sector.

Reflections on propositions

This is an appropriate juncture to reflect back on the indicative propositions outlined earlier. The first proposition suggested that *open innovation will occur most readily when it involves the integration of more modular and explicit forms of knowledge.* We further suggested that: *dependence on tacit and embedded forms of knowledge will be more difficult to accommodate within an open innovation process due to the complexity of governance mechanisms required*.

As noted above, modularization was reflected to some degree in the work breakdown and packages defined by the MOZART programme. However, the role of modularization was limited by the interdependence between partners created by the concurrent engineering methods adopted in the innovation process. The resulting reliance on the networks created by prior collaboration –effectively underpinning the allocation of work packages - gives some support to the proposition that: *where open innovation processes do require the integration of tacit knowledge, this will only be possible through relational mechanisms involving strong ties between network participants*

Another important factor highlighted by the case-study is the dynamic and transformative character of the innovation process. We noted previously, that governance mechanisms, especially their relationship-building or inhibiting effects, were likely to exert some influence on the innovation process. As stated: *the governance mechanisms adopted for open innovation are likely to evolve over time, with some path dependency in the course of their evolution – i.e. initial governance conditions are likely to exert an enduring influence.* Based on this, we speculated, first, that: *the initial adoption of formal mechanisms with positive relational effects, such as the joint venture form, is likely to encourage stronger ties and hence greater ability to integrate tacit and embedded forms of knowledge*. Second, we suggested that: *the adoption of formal mechanisms with negative relational effects (as with*

legalistic forms of contract), is likely to encourage weaker ties between firms, and hence greater ability to integrate explicit and modularized forms of knowledge.

Interestingly, the evidence from our case suggests that initially adopted governance mechanisms may be less influential than this suggests. Rather such mechanisms seem themselves to be adapted to shifting expectations attaching to the outcomes of the innovation process. Thus, concerns over appropriability seem to have prompted the adoption of closed networks as a relational mechanism enabling and encouraging greater reciprocity amongst partner firms. The strategy of limiting exploitation to closed groups of firms helped to alleviate concerns over appropriability – concerns which likewise ebbed and flowed with changing perceptions of the intellectual property potential of innovation outcomes. We can note, though, that this strategy is not without its own problems; closer dependence amongst partners, as noted by Oxley and Sampson (2004), being potentially confounding for any attempts to stake IP claims for one firm over another.

Theoretical and practical implications

Up to this point, we can say that the governance of MOZART reflects many of the insights derived from the existing literature on knowledge governance. Where it begins to part company with those existing views, however, is in relation to the stability of governance and the role which it plays within an open innovation process. Here it departs from an important strand in the existing literature which has sought to specify knowledge as a contingency variable in the design of organizational forms (e.g. Birkinshaw, Nobel and Riddestrale 2002). This strand of work has certainly illuminated those characteristics of knowledge processes which have important implications for governance. At the same time, however, this strand implies a static analysis of the relationship between knowledge process and governance mechanisms. This seems less relevant to the open innovation process discussed here for a number of reasons. First, such innovation processes are inherently dynamic. As noted in Nonaka's account (1994) they involve the episodic transformation of existing knowledge into new forms. As a result they create an almost continually shifting set of challenges for governance. The needs for openness to allow knowledge integration across boundaries may quickly be overturned should the new ideas thus created be seen as possessing significant value. At this point, concerns for appropriability may outweigh the need for openness resulting in a more exclusionary governance structure and closed, not open, networks. This pattern of

initially open forms of governance giving way to more closed forms is certainly apparent in some of the work packages within the MOZART programme.

A second feature of the MOZART programme which is not amenable to the contingency approach to governance is exemplified by the ITNET work package. This is actually one of those parts of the programme which moved from an initial position of sharing findings within the work package towards a more open approach to governance. It did so, however, as part of a strategy to increase its centrality within the programme as a whole. This involved eliciting the involvement of an expanding network of users from MOZART member organizations through an 'open source' approach to knowledge governance. 'Open source' has been widely discussed elsewhere (Pisano 2006; von Hippel and von Krogh 2003), and is seen as recasting old questions on the role of intellectual property protection in innovation. It does so by enabling the creation of a new source of value through the network externalities (Arthur 1989) arising from the widespread adoption of common systems and standards. This source of value is especially applicable to the development of IT systems. This helps to explain why the ITNET changed its governance towards a more open-source model since it sought to develop and diffuse common systems and standards as widely as possible amongst MOZART members. In this sense, therefore, we would argue that this shift highlights the limitations of a stable structure when more open governance can be a critical part of a consciously de-stabilizing innovation. In this sense, ITNET's approach to governance is compatible with Pisano's analysis of the appropriability benefits of more open innovation for established players in certain fields. By adopting an open standards approach, ITNET succeeded in leveraging its complementary capabilities (training, integration, development) much more effectively across the whole programme.

A further thought on the success of the ITNET project are its implications for the management of projects within an open innovation context. Such a context demands new strategies and skills from managers. As noted in the ITNET case, the ability of individual managers to champion their project across a wider network of organizations may be critical, and may involve a different set of skills to those required within a focal organization. Chesbrough (2004), for example, has likened the change in skills required between closed and open innovation to the difference between playing chess and playing poker. The open innovation 'game' with its multiple players and shifting stakes demands the poker-player's attention to the strategies of others, and the ability to use scarce information effectively. In the ITNET project, for example, we see the project leader's agency and skill in playing the

counter-card of openness in an environment where many other groups were developing closed networks.

Conclusions

As noted above, the complex governance structure of the MOZART programme and its sponsorship by the EU makes us cautious about over-generalizing its implications to other cases of open innovation. MOZART is partly a product of a unique institutional context and would not be replicable in other regional economies. On the other hand, as an extreme case, MOZART usefully illuminates many of the most acute governance challenges posed by open innovation. Thus, it underlined the extent to which such innovation poses genuine dilemmas for governance. These included, the challenge of addressing the task coordination needs of open innovation - requiring more open networks at certain points - while at the same time mitigating exchange hazards which leads towards closed networks. Since these challenges are linked by the knowledge integration requirement of open innovation, effective governance solutions are difficult to achieve.

A further dilemma, which has been highlighted in our discussion above, is between stability and change in the form of governance adopted. Because innovation proceeds sporadically and sometimes erratically from existing knowledge to new knowledge, it is difficult to sustain a particular governance solution over the course of the whole process. We also noted how, in the case of MOZART, this dilemma is exacerbated by the scope and complexity of the work involved. Speaking of other such 'mega-projects' as they term them, Miller and Hobbs argue that 'there is a sharp contrast between the binary, hierarchical and static nature of corporate principal-agent governance relations, and the time-dependent co-determination found in the network relations typical of the governance of mega-projects…' (Miller and Hobbs 2005: 47).

The implication of this kind of analysis is that the pursuit of stability in governance structures may be unrealistic and even undesirable in the development of more open forms of innovation. It may be more important that such structures are able to change and adapt to the shifting needs of knowledge integration than pursue a best fit with circumstances prevailing at a single point in time. This has important consequences for companies pursuing strategies of open innovation in particular. It would be simplistic to conclude that such strategies merely require more open forms of governance. Rather, the dynamics of the open innovation process make knowledge

governance an even more critical and explicit question for the organizations involved, precisely because stable institutional arrangements become somewhat less sustainable.

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FIGURE 1: THE GOVERNANCE CHALLENGE OF OPEN INNOVATION