To be Greener: Adaptation in Incremental Innovating Oilfield Chemistry

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Abstract

This paper draws cases of relationships from the international oil and gas industry's service sector. We focus on the supply of oilfield chemistry, which delivers greener chemical products and services to oil and gas companies to secure asset integrity and flow assurance across product facilities in context of conflicts of cost, performance and environmental regulations. The aim of this paper is to examine how adaptations take place in innovating greener chemistry. In the mature industry of oilfield chemistry, most innovations are taken place incrementally. A green chemical incremental model is developed to examine the role of actors' adaptation process, drivers of incremental innovation, resources in green chemistry product and service development, and interactions in innovation in the network consisting of oilfield services companies, oil and gas operators, chemical suppliers and regulators.

Key words:
adaptation; IMP; relationships; innovation; green chemistry

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INTRODUCTION

In industrial markets, companies are increasingly highly interdependent and interconnected within networks. Relationships in industrial sectors seem to be in a state of complexity and dynamic change. Business actors experience technology conflicts caused by competitors, customers and even regulators. Product research and development is perceived to be an important activity to create greater trust and market reputation, enlarged market share and increased profitability. Incremental innovation will never stop because business actors are involved in seeking products and services with better value.

In the oil and gas chemical industry, these values must meet the requirements of environmental and safety regulations, demonstrate good performance in solving customers' technical problems and lower the costs of production and use.

This research relates to adaptations in conflict settings (Finch, Zhang & Geiger, 2013). Adaptation plays an important role in managing conflic. In the industrial market, interaction in conflicts determines the behaviour of the actors and explains the driving forces that shape individual behaviour in markets (Håkansson and Snehota, 1995). According to Finch, Zhang and Geiger (2013), actors in the chemical industry experience conflict as a pervasive condition in business relationships. In terms of managing the pervasively perceived conflicts (e.g. of cost, regulation, and technology), actors take on a role of adaptation, creating and participating in certain conflict-aligned events in order to re-stabilize their relationships and maintain their value. Two types of adaptation exist in organizations: 'experiential learning, the idea that organizations and the people in them modify their actions on the basis of an evaluation of their experiences' (Denrell & March, 2001); and competitive 'selection and reproduction, the idea that organizations and the people in them are essentially unchanging, but survive and reproduce at different rates depending on their performance' (Denrell & March, 2001). Both forms of adaptation perform as devices for improving the fit between/within organizations and their business environments, requiring incremental innovation.

In the mature industry of oilfield chemicals, most innovations take place incrementally. This Study is developed to examine the role of actors' adaptations by examining the drivers of incremental innovation, green chemistry products and service development, and relationships in a network consisting of oilfield services companies, oil and gas operators, chemical suppliers and regulators. In this paper, we draw five cases of relationships, which also demonstrate processes of innovation. We focus on the adaptive role of the actors in establishing incremental innovation in relation to green chemicals and chemical services investigate our research question:

RQ: How do actors adapt to establish incremental innovation in conflicts?

CONFLICT IN NETWORKS

THE PERVASIVE CONFLICT

Conflict is insufficiently studied (De Dreu, 2005) within and across many scientific disciplines including philosophy, anthropology, psychology, sociology, politics, economics and organizational studies. Conflict theory is continuously developing and has an impact on business-to-business marketing and its practice. As March and Simon (1958) state, conflicts can be addressed through a process of problem solving, persuasion, bargaining and politics.

Conflict can be detected within an organization's routines or in a symbiotic relationship to continuing conflict (Nelson and Winter, 1982, p. 110). Routines are patterns of interactions that represent solutions to problems experienced in organizational behaviour (Pierce *et al*., 2002). Truces can be powerful responses to conflict, stultifying otherwise potentially beneficial consequences such as organizational development and innovation and adaptive incremental experiential learning in practice (Nelson and Winter, 1982, p. 111; Lounamaa and March, 1987; Pierce *et al*., 2002). In the framework of an interpretation of experience, conflicts of interest within/across organizations are identified through conflicting interpretations based on actors' roles (Levitt and March, 1988) and interpretations of the political and economic environment (March and Olsen, 1984). Cyert and March (1992, p. 215) discuss unresolved conflict, and the continual negotiation of the relationship between the interests of an organization, its subgroups and its individuals, such that 'consistency is rarely achieved and difficult to sustain'.

March (1999) extends the argument across the preferences and identities of organizations, groups and individuals, and with respect to time periods within broader interactive settings, which he describes as 'ecological networks' (March, 1999, p. 46). In such situations, non-violent conflict may be a long-standing and regular feature causing dynamics in/across organizations where arenas exist to process adaptations (Ostrom, 1998) and learning (Herriott *et al*., 1985).

Teece *et al*., (1997) develop the standard operating procedures first outlined by Cyert and March (1963) in their analysis of organizational behaviours by considering the concept of dynamic capabilities in a context of operating in conditions of rapid technological change. They also add more dimensions such as 'the make/buy decision, external ties, and technology' (Pierce *et al*., 2002, p. 88). Teece and Pisano (1994, p. 57) address the way in which dynamic capability 'emphasises the key role of strategic management in appropriately adapting, integrating, and re-configuring internal and external organizational skills, resources, and functional competences toward a changing environment' where firms are in strategic conflict to remain competitive in markets.

Organizations require to adapt their dynamic capabilities, 'modifying beliefs and behaviours by observing their own and others' experiences, possibly making inferences about the cause of those experiences, but in any event adjusting propensities to favour the replication of actions and beliefs that have been associated with favourable outcomes in the past' (March, 2008, p. 6). The behavioural approach addresses questions related to conditions of conflict beyond the individual or groups of individuals, such as resources, routines, adaptations, and operating procedures. It implies a process of interactive adjustment of organizations' behaviour as a result of experienced conflicts.

Organizations are adaptively rational, suggesting that learning and behaviours are conditioned by actors' experiences (Pierce *et al*., 2002). Actors experience pervasive conflict. Pondy (1967) states that conflict should be considered as a dynamic process, requiring '(1) antecedent conditions (e.g. scarcity of resources, politic differences) of conflictful behaviour; (2) affective states (e.g. stress, tension, hostility, anxiety, etc.) of the individuals involved; (3)

cognitive states of individuals, i.e. their perception or awareness of conflictful situations; and (4) conflictful behaviour, ranging from passive resistance to overt aggression'. Thomas (1992) proposes an event sequence process model for the analysis of conflicting frameworks in organizations. This addresses the elements of conflict awareness: thoughts and emotions, intentions, behaviour and consequences. The behavioural approaches influences our research questions, and suggests the ways in which actors, in the context of managing and managing in conflicts, can experience and make sense of conflicts and can adapt.

CONFLICT IN BUSINESS-TO-BUSINESS MARKETING

Conflict has its impact on business-to-business marketing research. Ehie (2010) comments that conflict has an impact on business operations, i.e. the facilitation and hampering of the performance of companies. In industrial markets, actors experience and participate in conflict positively, and are willing to produce satisfactory outcomes for both parties rather than allow a zero-sum conflict where only one party wins. Conflict can be easily identified between sales and marketing personnel (Le Meunier-FitzHugh *et al.*, 2011; Chartered Institute of Marketing, 2011). Le Meunier-FitzHugh *et al.* (2011) analyse interpersonal conflict between marketing managers and sales managers within an organization by considering three communication variables as antecedents in the structural model, indicating frequency, bidirectionality and quality. As well as at the interpersonal level in business markets, conflict can also be found across organizations' (or companies') boundaries, such as between suppliers and their customers in sustainable supply networks, between those in different marketing and distribution channels, and across supply chains (Chang and Gotcher, 2010; Duarte and Davies, 2003; Cheng and Sheu, 2012; Ndubisi, 2011; Plank *et al.*, 2006; Plank and Newell, 2007; Webb and Lambe, 2007).

Chang and Gotcher (2010) take an inter-organizational perspective on learning from conflict and explore occasions when conflict-coordination learning is used to resolve conflict by improving the capability to create value. Channel conflict is 'a situation in which one channel member perceives another channel member(s) to be engaged in behaviour that prevents or impedes it from achieving its goals' (Stern *et al.*, 1996, p. 306). Business market actors also perceive conflict from politics and from norms from regulators. Actors in business markets, for example, respond to new regulations. Veal and Mouzas (2011) consider the impact of regulations on business relationships, and the way regulations cause conflicts of interest in/between companies. They state that actors should interact with regulators regarding the creation of new regulations rather than just comply with the rules (Veal and Mouzas, 2011).

Research on conflict in business markets shows the impact of conflicts on organizational practice and performance. The impact is mainly dysfunctional and is resolved through the identification of goals, their divergence, the reasons for or antecedents of these divergences, and instruments of alignment - common with bargaining – such as incentives. Such resolution is supported by senior managerial involvement, and accompanied with dynamics in relationships. The entity at stake tends to be the direct value otherwise created by cross-functional interactions and exchanges (Lam and Chin, 2005), where adaptations take place.

INTERACTIVE ADAPTATION

To analyse interactions and events in the industrial market, this paper both focuses on actors and how they adapt to make exchanges happen, and examines the activities of actors regarding their experiences conflicts in networks. In the market studies approach, adaptations are considered to take place as markets perform and have relevance for market exchanges and business norms. Market exchanges are regarded as a process of adaptation, enabling exchanges to happen. Actors on both sides of an exchange will adapt to each other, and such adaptations have social characteristics embedded with the materialities (such as the techniques and resources in question) of that exchange. The IMP approach, however, concentrates on long-standing interactions and networks, where actors, resources and activities function to establish adaptations in networks rather than just in dyadic exchanges. In this section, I analyse adaptation as an interactive approach in business markets, and further examine it in a long-standing, distributed and conflicting context through investigating business responses to conflicts of cost, regulation and technology.

THE CONCEPT OF ADAPTATION

Adaptation is an underdeveloped concept in the research on market exchanges and business interactions. Brennan and Turnbull (1996) define buyer and seller adaptions as ‘behavioural modifications made by one company, at the individual, group, or corporate level, to meet the specific needs of another organization'. This stresses the role of relationships and interactions (one or both parties) in adaptations. They define adaptations as ‘modifications at the individual, group or corporate level which are carried out by one or both parties in an exchange relationship in order to suit new needs or conditions, and which are designed initially for that specific relationship’. These definitions address the purpose and dyadic structure of adaptation but lack the ‘content in adaptation’. Håkansson (1982) points out that adaptations can take place in product development, incremental innovation, investment, financial arrangements, information routines or social relations; these adaptations tend to make relationship more productive.

DYADIC ADAPTATION

IMP researchers have comprehensively analysed adaptations in a dyadic context, focusing mainly on inter-firm adaptation. Inter-firm adaptation is described as a key interaction in business relationships (Brennan and Turnbull, 1995). Adaptive behaviour functions in buyer–seller relationships by influencing the activities of market actors (Brennan and Turnbull, 1999). Brennan *et al.*, (2003) review classifications of adaptations, concluding that adaptations contribute to the development of mutual trust and the building of commitment. They adopt the concept of the power balance in a relationship, stating that unilateral adaptations are a response to power imbalances. The role of power in interactions also influences the structures of adaptations, which suggests that an actor with weaker power would have to be the one to adapt to the stronger actor (Hallen *et al.*, 1991). Brennan and Turnbull (1999) comment that ‘adaptations tend to increase the level of trust and commitment in the relationships’. But Jeffries and Reed (2000) argue that trust should be kept to within a certain range, and say that ‘too much trust is as bad as too little trust’. Therefore, contracts (agreements) and social norms (governance structures) can assist in enhancing actors’ performances both individually and in combination under conditions and forms of transactional high uncertainty (Cannon *et al.*, 2000). In industrial markets, suppliers invest in adaptation as a strategy in order to retain their business customers or maintain business relationships (Ahmad and Buttle, 2001). Adaptations do not just take place among suppliers;

customers also adapt to certain factors such as changes in the business environment or to regulations (Halinen, 1994). Parties adapt as part of a process to identify factors that can facilitate or hinder environmental changes (Canning and Hanmer-Lloyd, 2001a). The process of adaptation involves events, activities and stages. The ability of a firm to undertake adaptations to change of technology is based on an interactive process of mobilizing resources, and reconfiguring of aggregate resources take place through the connecting functions of business relationships (Chou and Zolkiewski, 2012a).

ADAPTATION IN NETWORKS

A change in business environment is considered to motivate adaptations. The intra-firm and inter-firm adaptations process model of Brennan and Canning (2002) shows that adaptations contribute to the uncertainty caused by changing business conditions, but also assist in the better utilisation of the resources tied to relationships. Hagberg-Andersson (2006) considers adaptation as a response to different parties in supply networks, and that it is therefore a response to '[a] buyer, another supplier in the supply chain, another potential buyer or to industry norms, for example environmental requirements'. In industrial markets, other parties may become involved in the process of adaptation, and the study of adaptation should be set in the context of networks rather than just dyadic relationships.

Although business relationships in networks begin with a dyad, dyads do not capture the essence of a network (Choi and Wu, 2009). Choi and Wu identify nine triadic archetypes of buyer–supplier–supplier relationships, where adaptations happen among triads. Wuyts, *et al.*, (2004) examine buyers' preferences for specific patterns of relationship among the buyer, intermediary vendors and suppliers of complex products, identifying buyers' value sequences for strong and weak ties. Buyers' value provides strong ties between the vendor and suppliers in the network. Madhavan *et al.*, (2004) propose clustering and countering constructs as potential drivers of the triadic structure in which three companies can all have direct ties with each other. This contributes to the analysis of competitor alliance networks. Madhavan *et al.*, (2004) also stress that the potential drivers of conflict vary across geographic and technological areas.

Adaptation can be multi-sited, involving several parties. The existing research has shown that intermediary vendors, other actors in the supply chain or other actors in distribution channels participate in adaptations and trust-building (Choi and Wu, 2009; Wuyts, *et al.*, 2004; Svensson, 2004; Phillips *et al.*, 1998), but there is limited research about actors' adaptations in more complex networks which involve industrial and government regulations.

RESEARCH METHOD

CASE STUDIES

In applying and developing the concepts discussed in above, we recognize that, while identifiable as constructs, some have meanings that are ambiguous or refer to processes that are likely to emerge over time. Thus, in this paper, we take the case study as the overall research design. Case study methods are used for a wide variety of research questions, such as questions on organizational performance, project design, policy making and analysis, business relationships and behaviours. Dubois and Gibbert (2010) studied the interplay between theory, method and empirical phenomena when particularly considering case study research in the context of industrial markets. Case study research is commonly adopted in business-to-business marketing research (Easton, 1995; Dubois and Gadde, 2002; Halinen and Törnroos, 2005; Borghini et al., 2010; Dubois and Araujo, 2004; Ford and Redwood, 2005). According to Woodside and Wilson (2003), industrial marketing substantially focuses on 'the decisions and behaviours by individuals and groups within and between organizations'. Individual responders can retrieve information and be willing to report his/her experience or perceived information, usually followed by a post hoc sequence of events that happens over several days, weeks, months or even years. Woodside and Wilson (2003) stress the importance of research focused on the cognition of individual market actors, such as 'what they perceive', 'framing what they perceive' and 'interpreting what they have done including how they go about solving problems and the results of their enactments – including the nuances, contingencies, in automatic and controlled thinking processes'. They conclude that case study research can contribute to a deep understanding of the actors, interactions, sentiments and behaviours occurring for specific processes through time'.

Because of the nature of phenomena in industrial marketing, a case study established in this area is different (Piekkari et al., 2010). The industrial networks present researchers with challenges 'since they do not constitute closed, bounded or clearly defined systems' (Dubois and Gibbert, 2010). In terms of addressing the interplay between theory, method and empirical phenomena, Dubois and Gibbert (2010) compare two reasoning approaches (deductive and abductive) and propose that the abduction approach helps researchers travel 'back and forth' between theory and phenomenon so that a general theory builds from 'dynamically combining multiple steps of induction and deduction that often involves re-interviewing and revising sense-making views of executives participating in implemented strategies', based on how informants interpret investigators' interpretations of antecedents, actions, and outcomes (Dubois and Gibbert 2010).

IDENTIFYING CASES

The research setting in this paper has been introduced in previous sections. We begin by conceptualizing the business setting as different regimes or configuration of a network: normal business, conflict of interest, and adaptive activities. All three regimes occur simultaneously among the overlapping groups of companies, regulators and other organizations. In the case of the oilfield chemical industry, normal business has systemic qualities, which are identified, formalized and made stable by Chemical Management Service (CMS) contracts and by the processes of regulation. Large oil operating companies with groups of production facilities (or assets) offer Chemical Management Service contracts for four or five years, and oilfield chemical service companies tender for these. In one of our interviews, Malcolm, a sales manager at ProChemicals, describes the process in this way:

> The driver from the oil and gas companies has been to move towards longer-term contracts with single sourcing or dual sourcing because they believe that they get a better price by doing that. We certainly reduce the pricing to gain those longer-term contracts because it gets us a bigger market share. If we don't win contracts, there will be no chance for us to have a business.

CMSs provide incentives for aligning the interests of oilfield chemical service companies and oil companies in normal business relationships. In part, they allow incumbent chemists to undertake product development, as a form of adaptation, helped by a greater familiarity with an oil company's production facilities. This paper is interested in conflicts, events, and cognitive emotions in and around normal business relationships and interactions.

We draw upon ideas from five cases of relationship in normal business: (1) an oilfield chemical service company in a relationship with a chemical supplier and addressing problems caused by environmental regulations; (2) a chemical supplier company in a relationship with an international chemistry service company dealing with regional regulations; (3) an oil field chemistry service company working between chemical suppliers and oil and gas operators to resolve technical problems; (4) an oilfield chemistry service company in a relationship with other actors investing in research organizations; and (5) a chemistry service company in a relationship with their supplier to test and feedback on product performance. Adaptations are required, for example, because economies of scale are important to chemical companies in producing near-commodity products (chemical bases); economies of re-use are important to oilfield service companies as a basis for incremental innovation in adapting established solutions; and flow assurance and assets-integrity are vital to oil companies, along with overall cost control across the cluster of the assets that form business units.

Case	Description
Relationship 1	Relationship between a chemical supply company with an oilfield service company in producing alternatives to a regulation
Relationship 2	Incremental innovation relationship between/among a chemical supply company, an international oilfield service company and Norwegian regulators.
Relationship 3	Triadic relationship of an oilfield service company, supply company and oil and gas operating company in a project to resolve chemical problems.
Relationship 4	Multi-site relationship among an oilfield service company, a chemical supply company, an oil and gas operating company, and a research organization to develop products ahead of need.
Relationship 5	Relationship of normal interaction between a chemical supply company and a service company on the evaluation and testing of a new product.

Table 1: Overview of the five identified cases of relationships

DATA COLLECTION

Data in the case study method can be collected by multiple means of qualitative research techniques, such as 'interviews, document analysis and various modes of observation, which blurs the boundaries between context and phenomenon and enables a research obtain data in a real-life setting' (Dubois and Gibbert, 2010). Data were collected through a combination of methods, including through research interviews, observation, attending industry conferences and exhibitions, reading industry and company reports and documents. We gathered a primary dataset through a combination of research interviews, observation, attending industry conferences and industry exhibitions, and reading industry and company reports and documents. Observation is a set of complex arrangements of feelings and perception rather than just looking at something and searching for the facts. Observation takes place where actors are involved in the behaviours under study. Observation provides an opportunity to get beyond people's opinions and self-interpretations of their attitudes and behaviours towards an evaluation of their actions in practice. Interviews are usually held without close observation (Watson, 2011). Watson indicated that what distinguishes the ethnographic interview from other types of interview is that it is one in which the subject feels confident to challenge the researcher and contribute to shaping the conversation, and avoids falling into line with the interviewer's priorities and preconceptions. Interviewees are normally made up of people of a particular background, or who share a particular experience. Although a set of questions is usually designed structurally before the interview, it will be adjusted during the interview as a result of the human interaction between the researcher and the interviewees.

We began fieldwork in early 2011, identifying the five cases describe above and in Table 1 based on data from the interviews and observations (see appendix 1 and 2, including 16 interviews and 7 observations). I faced three challenges in the process of fieldwork data collection: (1) the difficulty of getting access to the researched companies because of the confidentiality agreements between them; (2) the fact that most of the interviewees were too busy to be interviewed; and (3) the fact that industrial conferences are mainly open to registered company members. I made efforts to overcome these challenges, including: (1) adopting a variety of methods to contact relevant people in the industry (Arnould and Wallendorf, 1994; Piekkari *et al.*, 2010; Sloan and Oliver, 2013), such as searching from LinkedIn.com and sending emails, meeting people at industry conferences or workshops, and recommendations from interviewees; (2) contacting regulatory or industry conference organisers for permission to attend as a non-participating observer; and (3) trying to get someone who had just retired from the industry or worked as consultant to agree to be interviewed.

CODING AND ANALYZING DATA

In terms of analysing the data, a cross-case comparison method was adopted and the data were coded using QSR Nvivo, version 10, which provides ways to organize unstructured data by themes, people or places. Nvivo provides ways to organize data by themes, people or places, which is known as coding. Nvivo 10 is used to analyse different forms of unstructured data. A node in Nvivo is a container to gather ideas, thoughts and definitions about the data and selected texts in the data sources. I established a project in Nvivo 10 and imported the collected industrial documents and reports, interview audios and transcripts, observation notes and photos into Nvivo as sources for coding. I chose a way of organizing material into themes through coding. By organizing the data in this way, I identified themes based on the research aim and questions. Nine main themes were identified as nodes for coding the imported data. The main themes were coded as conflicts, events, triggered emotions, adaptive activities, interactions, and relationships (shown in Figure 1).

Figure 1: **Tree map of Nvivo nodes comparison**

FINDINGS

In terms of answering the research question, we review the roles of actors and their activities within the five identified cases of relationships in green chemistry industry. There seem to be some kind of adaptation behind these relationships. Wherever interactions and relationships take place, actors work in a pervasive condition of conflict (Finch, Zhang & Geiger, 2013). The oilfield chemists, along with other actors in the oil field industry, take an adaptive role to make exchanges happen by means of providing and exchanging chemicals and chemical services for their oil company customers, while facing and experiencing conflicts with their particular interests. In the oilfield chemical industry, adaptations take place in the process of interaction, either within or between organizations. Such adaptations function not only through buyer–seller relationships, but also through involving other actors. In this section, we draw out the adaptive role of the actors within the interactions in the five identified relationship cases, and further illustrate why and how incremental innovation takes place within the oilfield chemical production network.

ADAPTIVE INTERACTIONS

In normal business relationships in the North Sea oilfield chemicals industry, the actors – oilfield chemists, oilfield service companies, large oil and gas operators, regulators and others – maintain relatively stable and long-term relationships but with a dynamism within networks. As Augier & March (2008, p. 3) state, a firm is 'an adaptive, a coalition between different individuals and groups of individuals in the firm, each having different goals and hence possibly in conflict'. The dynamics of the business environment motivate the adaptive interactions of actors, which can be dyadic, sometimes triadic and even multi-sited. Looking at the identified cases of conflicts from the perspective of interactions, each case contains adaptive interactions by which actors manage (in) pervasive conflicts (see Table1).

Case	Adaptive interactions	Consequences
Case 1	• Chemical supplier companies interact with their oilfield chemical customers with a regulatory (OSPAR) impact on demulsifier production. • Oilfield chemical companies interact with their large oil company customers by using less efficient chemicals. • Interaction between oilfield chemical company and regulators over concerns about the disclosure of formulations.	• Substitution & regulatory agenda • Long term & short term planning • Incremental innovation • Chemical Management Service (CMS) contract • Negotiation under contract • Licensing • Cost added
Case 2	• Oilfield service companies interact with oil&gas companies with products which need testing and use in particular regulatory regions. • Interactions also exist between chemical companies and regional testing agencies.	• Regional standard regulatory testing • Bargaining with regulators • Industry collaboration for incremental innovation • Cost added
Case 3	• Interactions between oilfield service companies and oil companies over particular technical problems. • Companies interact over CMS contract.	• CMS contracts • New projects for incremental innovation • Cost added • Assessing portfolio

Case 4	• Beyond CMS contract, oilfield service company interacts within network and with universities in terms of taking their current or future research.	• Project agenda • Incremental innovation • Cost • Assessing portfolio
Case 5	• Interactions for establishing more effective 'green chemistry' between chemical companies.	• Incremental innovation • Cost added • Contest

Table 1: Adaptive interactions within the cases

Within the five relationship case studies, interactions (see Table 1) take place adaptively with the purpose of establishing and marketing 'green' chemistry. For instance, actors participate in (1) the rearrangement of relationships in business interactions as a result of the impacts of new regulations; (2) new forms of resource interactions and technical problem solutions from the technology updates in the industry; and (3) seeking for lower cost, which becomes a main issue in terms of maintaining long-term business relationships.

INNOVATION AS ADAPTATION

Table 2 summarizes actors' interactions and their consequences in the five relationship case studies. As NAWO cannot provide sufficient evidence for their demulsifier (alkyl phenyl ethoxylate resins) to prove that the product is suitable to meet the OSPAR regulations, NAWO has to make adaptations so that they adopt other less efficient demulsifiers to use in the North Sea. Tony, the NAWO's product manager, said:

> We have no choice but have to adapt to the regulation standard and change formulation, which means a new round of R&D will be established.

As illustrated, not only does a chemical supplier company face regulatory adaptations but a chemical service company also meets the same need for regulatory adaptations. In the same case study, ProChemicals provides scale and corrosion treatment to Large Oil, under the long-term CMS contract. Although the CMS contract maintains stable relationships between ProChemicals and Large Oil, negotiations take place in terms of adapting to seek better treatments for corrosion problems under the North Sea environmental regulation requirements. As David said:

> We never stop innovating over new corrosion inhibitors for corrosion problems because our current product, polyaspartate, performs so poorly in operation.

ProChemcials also makes adaptations to product performance for the purpose of making profits while operating under the regulations. It also invests money in researching and developing products with better performance with a view, on the one hand, to replacing polyaspartate, and on the other hand to avoiding the risk of the regulations changing to regulate the quantities of product used rather than the substances themselves. There is cost involved in developing new environmentally acceptable products with good performance to gain market share. David, ProChemicals' oilfield chemist, stated:

> …We are aiming to get market share in this segment of market. We launched a project to develop alternatives to our current corrosion inhibitors. We made remarkable progress but we cannot use our newly developed products. APGs [the product in question] can be used in a number of applications as corrosion inhibitors. They can be classed as truly green, having low environmental impact, being fully biodegradable and being derived from sustainable natural rather than synthetic sources; however their uptake is limited as their comparative unit costs are much more than other chemicals. In term of this, we prefer to use alternatives that are cheaper but not as green as APGs…

As explained by David, innovation projects to produce better performing corrosion inhibitors are set up under or beyond the CMS contract. Whether the product can be used on not is determined by the unit cost of the products rather than just by regulatory pressure.

Adaptation to regulations also emerges in Case 2, where a chemical company invests and adds cost to their products in response to due to regional regulations. The situation that KTI faces, which is that the well-performing biocide, Tetrakis Hydroxymethyl Phosphonium Sulfate (THPS), cannot meet the Norwegian environmental regulations, drives them to invest to find alternatives which are more biodegradable, less bio-accumulating, and less toxic than the chemicals that can be used in other areas of North Sea so that they can pass the Norwegian regulatory testing process. Tao, from KTI, commented:

> …THPS will not be acceptable to Norwegian regulation although it performs well in other areas. Within KTI, we set up meetings for the project of funding R&D into alternatives with better or at least the same performance as THPS but which can be used in Norway…

The adaptations to regulations in Case 1 and Case 2, which bring about cause incremental innovations in alternative chemicals, require the capability of actors to manage risks and plan for changes of norms. Both chemical suppliers companies and chemical service companies tend to minimise the uncertainties caused by changes of regulation or new regulatory impacts.

Adaptations in Case 3 and Case 5 focus on technology and technical solutions to chemistry problems, where chemical services companies work between chemical suppliers and large oilfield operators. An oilfield chemist in Case 3 took on an adaptive role of innovation within the long-standing relationships in order to solve technical problems. The process of solving technical problems requires collaboration within the industry. Case 3 also illustrates the process of incremental innovation in relation to products to deal with particular chemical problems faced by an oilfield chemist: (1) getting the idea and concept of the innovation (from a problem); (2) evaluating resources; (3) research and development; (4) trialing; and (5) launch/use the product. Monjit, GD Solutions' R&D manager, described it in this way:

> Problems need to be solved under the CMS contract, which can be a five year collaboration or even longer. We face the difficulty that we cannot always deal with the same problem with the same formulations because of regulatory or

> technology issues. We hold the CMS contract, which means we have an obligation to balance both the long-term and short-term benefits in the way we tackle this:

Balancing long-term and short-term benefits requires actors to be able to react to market needs and to forecast the risks of using chemical products under regulations. This requires a long-term or short-term innovation project to evaluate and address problems by optimizing the current product portfolio. Monjit added:

> Short-term innovation projects were also established under the contract with the oil and gas operators. Most of the innovation took place in-house. We set up a group to evaluate and establish R&D to solve the chemical problem in oil and gas production.

Case 5 describes another method of adaptive innovation, which broadens the network of actors in chemical production. In the face of enhanced regulation and technical problems going beyond CMS contracts, innovation takes place incrementally as the actors are usually unwilling to add the costs necessary to innovate. Collaborations across the industry are one approach to getting problems solved. These can involve a series of adaptive activities, such as developing alternative solutions for chemical problems, environmental regulatory testing, interacting with Oilfield Chemical Companies and Oil Companies, tests and feedback trials before launching the products, etc. As Claire stated in Case 5:

> …Product portfolio decides the direction of our R&D, whether to go forward or to stop it. Having a longer-term perspective of the entire product portfolio usually encourages more effective use of time, money and other resources. Thus, a well-scheduled R&D agenda makes for successful R&D projects…

The adaptive interactions take place over several sites in Case 4, where oilfield services companies which were encountering cost issues adaptively aligned with other research organizations to increase their technical capability ahead of demand. Adaptations in the green chemistry market are multi-sited, and involve a range of actors who are allocated different segments of the markets. To resolve the conflicts between regulations and product performance, actors choose to adapt product performance. This results in other adaptations or projects with significant material and technological consequences, leading to innovations. Multi-sitedness is a feature of this incremental innovation as the network widens across the industry. Service companies also interact with their suppliers on innovations in relation to problems of meeting the regulations, getting better performance or/and reducing cost. There are also a few industry-wide organizations where oil companies and chemical suppliers meet, often as joint-industry applied research projects which function similarly to a research organization. Oil companies require products that satisfy the regulatory requirements and these can be too expensive or complex for a single chemical services company or chemicals supplier to develop. Suppliers and operators construct alliances over research interests and market needs. Any chemical supplier, chemistry service company, or oil company can join and get research commissioned conditional upon sharing the results.

A common feature across the case studies and across the ways in which adaptations are formulated and take place is how chemical service companies, working between chemical suppliers and oil companies, make interactive innovations happen to meet the changing business environment and environmental changes. Actors have to make adaptations to balance meeting the regulations and the pressures of their cost base, prior to any adaptations as a result of other factors. The adaptations result in innovations which link actors through the process of getting technical problems solved within the CMS contract. These innovations require significant incremental investment, for instance in labs, in tendering processes for longer-term contracts, in employing scientists, in R&D projects with chemical suppliers or in joint-industry projects, in working with independent labs, in forming an industry association. Innovations in the case studies have social characteristics embedded with materialities which would develop incrementally in their normal business relationships, usually driven by CMS contract and cost issues.

DRIVERS OF INCREMENTAL INNOVATION

CMS CONTRACT AND INNOVATION

> …If you look at the last 50 or so years in the North Sea, the driver has been from the oil and gas industry to move towards longer-term contracts with single or dual sourcing because they believe that they get a better process by doing that. ...
>
> (Commented by Monjit, chemist from GD Solutions)

Monjit stressed how important a CMS contract is to a chemical service company. Large oil and gas operators who find new oil and gas fields or technical problems in their fields usually start a CMS contract. CMS contracts are the normal way of working and connect actors in making interactions. Due to the confidentialities, I found it hard to get into details of any CMS contracts in the industry, but can luckily interviewed some independent consultant who had been dealing with CMS for chemical service companies or large oil and gas operators. I identify the importance of CMS contract in researching actors' interactions and consequences by examining business activities associated with the CMS contracts in our five selected cases.

By revising the Case 1, ProChemicals interacts with Large Oil under a five-year CMS contract. The interactions not only refer to normal activities of chemical problemsolving and consulting, but also include some additional innovations to address specific problems encountered. Malcolm said:

> …Long-term contracts are considered by actors to be a win-win situation. Oil and gas companies will reward service companies if the service companies help them to solve particular problems. But a reward only really exists for us if we get the contract. That does encourage incremental innovation. …

For a service company, tendering for a CMS contract is their main business strategy in terms of getting market share. In the upstream oil and gas chemicals industry, it is vital for service companies, who work between chemical suppliers and large oil and gas operators, to plan for long-term incremental innovation as well as for their short-term innovation strategy, i.e. their core portfolio strategy. These can help them in tendering for CMS contracts by reducing the bidding price. Malcolm added:

> …We certainly try to optimize the product portfolio in terms of reducing the pricing to gain those longer-term contracts because it gets us a bigger market share. If we don't win contracts, there will be no chance for us to have a business. We innovate for contracts and services required in existing contracts, requiring investment in techniques and expertise. Also, we innovate for potential customers if we think it's necessary. …

Not all incremental innovations take place under the CMS contract. For instance, MIC Chemicals in Case 4 invest in and develop products beyond the requirements of any of their current contracts. Such innovations are established in advance of market demand and for the market per se, requiring enhanced forecasting capability for their R&D strategy. It results in a change of relationships through the adoption of other resources in networks. MIC Chemicals in Case 4 invests in an industrial research organization dealing with a problem of scale and flow assurance. They have had great success in containing costs through this way of making incremental innovations. The project they invested in, along with the other products in their portfolio, helped them to achieve four five-year contracts.

Tendering for CMS contracts integrates planning capability and the mobilizing of resources such as capital, chemists, current products and product portfolios, regulations, etc., as well as an incremental innovation team tasked by the CMS contract or a CMS contract tendering project.

As Norway operates to a higher regulatory standard, Tetrakis Hydroxymethyl Phosphonium Sulfate (THPS), the biocide that KTI uses in other countries, cannot be used there. Under a five year CMS contract with Cold Oil, KTI has to provide products from their portfolio which perform more or less the same as THPS. But the alternatives they find are much more expensive than THPS. As Matthew stated in Case 2, KTI has conflicting goals, working as both a selling and a buying organization. As a selling organization, KTI aims to maximize its profitability. But on the other side, the large oil and gas operators, as the receiving organizations, are keen on securing the cheapest price and best product performance. Thus, KIT has to invest in innovation to find alternatives at a lower cost so that they can sell them and increase their profits.

CMS contracts encourage not only the chemical service companies but also their suppliers to innovate, pushed by the chemical services companies. Malcolm explained:

> … We also require our suppliers to R&D products for us for special use with their technology when we get a contract. It usually comes with projects. We only fund projects for products that the companies do not often use or they will invest in facilities and technologies by themselves. They invest in building laboratories to undertake experiments and tests, and having their products tested in third party labs in order to acquire licenses to use these as products with their customers. We help them to test under the confidentiality agreement. …

A CMS contract connects chemical services companies and oil and gas operators with technical and chemical services problems. Under CMS contracts, a service company invests or requires their chemical suppliers to invest in incremental innovations to optimize their product portfolios, on the one hand to meet the technical requirements from their customers, and on the other hand to meet their own demand for products at lower cost, which becomes another driver of incremental innovation.

Cost and innovation

Cost

After making a cross-comparison of the five case studies of relationships (Table 1), it is clear that all of them are related to product research and development in terms of seeking lower cost products with the same or better performance. As Malcolm stated:

> …We make every effort to reduce the cost as much as possible. It continuously reduces the cost from the chemical suppliers sides. We have to do a lot to justify the price. …

Actors in the oil and gas chemical companies minimise uncertainty by providing actors with the benefits they are looking for, whether those be financial, social or regulatory. In the process, reducing and balancing costs in delivering and exchanging chemicals and chemical services, enabling product portfolio management and the execution of incremental innovation projects in a more adaptive and collaborative way all become effective ways to reach their business goals.

Containing costs gives a competitive advantage to actors in terms of winning a long-term business contract development, and this also directly drives incremental innovation. Cost-driven innovation exhibits a processual quality, developing over a long timeframe, and becoming seen as the normal way of doing business. Actors contain costs through identifying and allocating specific resources to projects, calculating materialities, optimising the product portfolio and deciding on the style of incremental innovation (Figure 1).

Evaluation

In relation to long-term planning, actors in the upstream oil and gas chemical industry evaluate and forecast the technical needs of their customers and changing regulatory requirements. Incremental innovation plays a role that runs across siloed product and portfolio planning as well as short-term planning for a particular chemical problem or long-term for business planning. Once a decision to go for incremental innovation has been made, actors tend to evaluate their entire portfolio and R&D capability. Evaluations can take several forms:

(1) Self-evaluation: chemical service companies evaluate their own R&D capability, including capital, current product portfolios, labs, chemists, time, etc.;
(2) Market evaluation: evaluations being made in relation to market actors, including business partners and competitors. Actors planning innovation evaluate the market's needs and potential market shares, their competitors' and their own product portfolios, and their current and potential customers;
(3) Regulatory evaluation: actors assess environmental regulation, regional regulations, and industrial regulation. Incremental innovation is highly influenced by the regulation agenda and substitution orders for particular chemicals or formulations.

In facing chemical problems, chemical service companies, chemical suppliers and oil and gas operators become connected in projects to innovate and test for solutions as routine. Claire from SurChem in Case 5 briefly described their R&D evaluation:

(1) Looking into the product requirements from the point of view of a service company customer;
(2) Discussing ideas and concepts for incremental innovation;
(3) Assessing the (regional) regulatory requirements, cost and product performance within their current product portfolio;
(4) Evaluating the market and talking to customers about their potential needs;
(5) Decision being made to innovate or not.

The cost and the outcome of the evaluation become main issues in deciding the future of the R&D process and helping actors choose the style of innovation project – i.e. in-house, through a bilateral relationship, or through a cross-industry project.

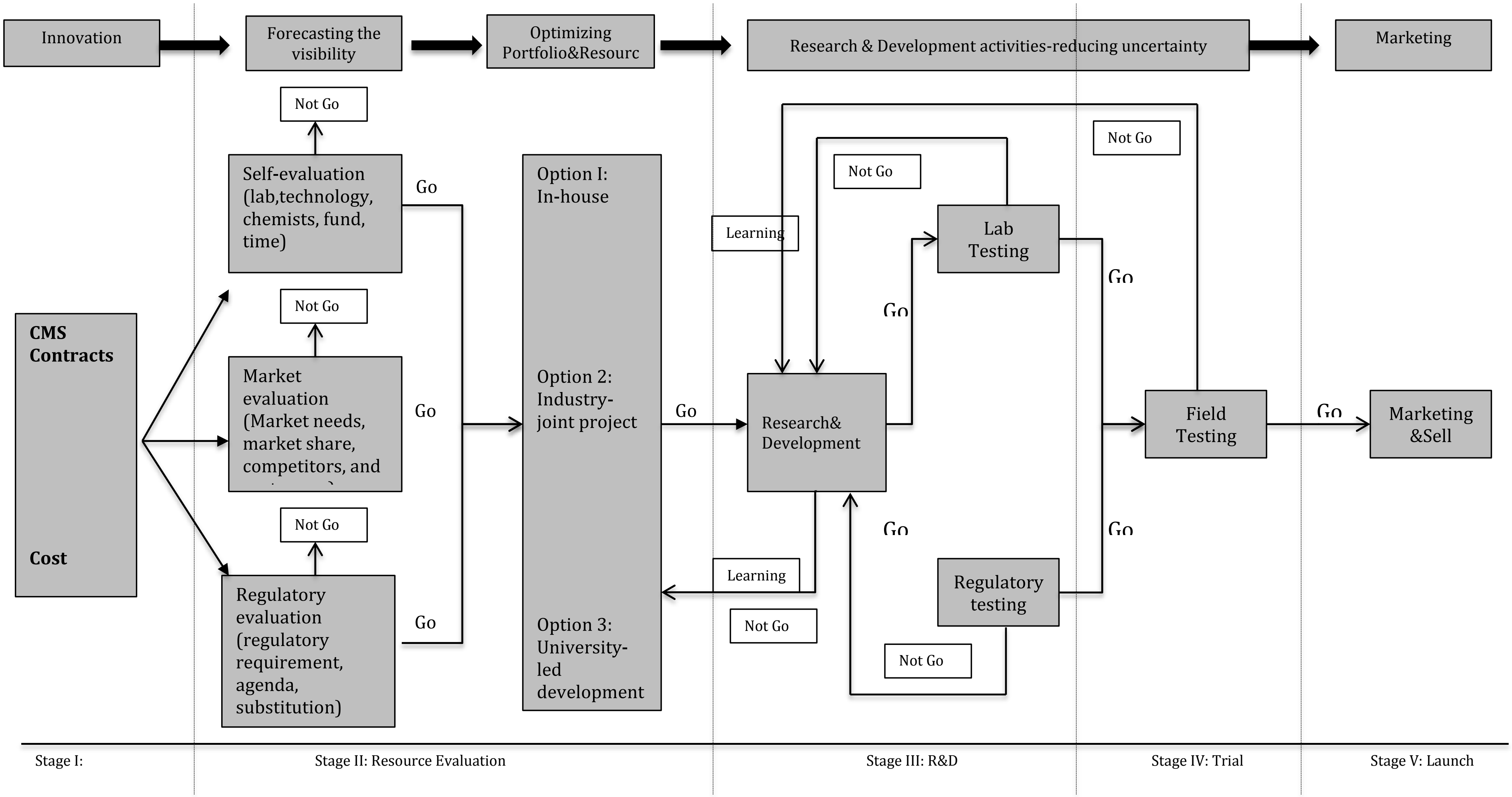

Figure 2. Incremental innovation model

DISCUSSIONS:

INCREMENTAL INNOVATION IN NORMAL BUSINESS

INNOVATION PROCESS MODEL

Incremental innovation for product development is the dominant form of adaptation in the oil and gas chemical industry as conflicts are experienced pervasively by actors and need to be resolved. Based on the five case studies of relationships in this research, an incremental innovation process model is developed in this section (Figure 2).

The upstream oil and gas chemical markets are mature. Most innovations are undertaken incrementally as part of normal business in a highly regulated and cost-driven context. The framework of the process model of incremental innovation for ‘green chemicals’ is to enable us to understand the interactions and resources in a processual way.

IDEAS AND CONCEPT

An idea and concept for innovation starts from lessons learned from the industry and customers either under or beyond the CMS contract. An innovative idea for chemicals develops from encountering a chemical problem (as in Case 1, Case 2, Case 3 and Case 5), regulation requirements (as in Case 1 and Case 2) and cost issues (as in Case 4). Ideas are also formed as a result of critical events (mentioned in Study 2, Chapter 7), where industrial technology conferences and workshops are held for the exchange of information. Once established, the idea has to be evaluated to decide whether resources should be committed to it.

Product ideas commonly spring from a number of sources, such as encountered technical problems, drivers of innovation (CMS contracts or cost), regulation, etc. The concept is a more detailed stage to better define exactly what the product is to be in relation to markets or customer needs. For example, in Case 2, Biocide Tetrakis Hydroxymethyl Phosphonium Sulfate (THPS) is no longer to be used due to the higher hazardous standard in Norway. KTI plans to develop alternatives with the concept of longer-term biodegradation to meet Norway’s standards. The process of forming a concept for innovation is a process of making markets and evaluating the resources that can be adopted. As Roy said (in Case 2):

> …Meetings are held with more frequency than usual to discuss ideas and concepts before establishing a new innovation process, which is mainly cross-departmental within our firm, and sometimes with our customers. …
>
> … We also face challenges at this point, such as enabling the planning process to take place among the different functional areas such as operations, R&D, marketing and finance, reducing long-term planning and forecasting errors, increasing visibility and collaborations with partners, suppliers and customers.

In the stage of idea and concept, transparency and visibility among executive planning groups makes for a less error-prone and more robust planning process. Following this stage, a detailed portfolio and resources evaluation takes place.

EVALUATION PORTFOLIO AND RESOURCES

The initial evaluation is a process of reviewing the current portfolio to see whether there is any product or chemical, which would provide a solution to the problem. Then this is followed up with the three evaluations, i.e. self-evaluation, market evaluation and regulatory evaluation.

Time and cost are crucial in terms of deciding whether to innovate themselves or buy products from the market. In Case 3, GD Solutions encountered the problem of gas well deliquification. Based on the portfolio and resources evaluation, GD Solutions decided to involve their suppliers to provide FAL rather than make incremental innovations by themselves. This required a broader industry collaboration involving GD Solutions, FAL (supplier) and Mature Oil (customer).

In contrast, in Case 4, MIC Chemicals evaluated and decided to invest in incremental innovation as a result of its forecasting of the market potential. Driven by cost, MIC Chemicals chose to collaborate in a joint-industry project led by a university research centre. Evaluations help develop ideas and concepts into projects, requiring the optimization of internal and external resources for technical appraisal. If the business decides to go ahead, it must then decide on which style of incremental innovation to use. The R&D is then established. Three styles of incremental innovation are undertaken in the oil and gas chemical industry, i.e. in-house (as in Case 1 and 2), industrial-joint project (as in Case 3 and 5), and university-led development (as in Case 4).

R&D

The research and development is the main stage of incremental innovation and requires interactions and allocating resources between actors in the industry. Product research and development is considered as an important activity in obtaining CMS contracts and leading to a stable market position for actors. In Case 1, the R&D is established by an oilfield chemist, who develops a new alternative demulsifier to meet the regulatory requirements. In Cases 3, 4, and 5, resources and interactions across the industry become vital to make innovation happen. The R&D projects take place by means of in-house projects, industrial collaboration projects and science-to-business (led by research organizations). The testing stage is the validation of the technical and regulatory performance in use. For oil and gas chemistry product innovation, because of its hazardous nature, lab testing and regulatory testing is undertaken before sending the product to trial.

TRIAL AND LAUNCH

The trial stage refers to ‘sample testing’ in real sites, allowing chemical service companies to put samples of their own or samples from their chemical suppliers to be tested in field under a secrecy agreement. The trialling is undertaken to reduce the uncertainties of R&D. Testing encourages collaborative interactions within networks, such as field testing, producing feedback reports, further discussing the R&D and innovation agenda, etc. If all the testing goes well, the products will be produced for commercial use and launched into the market.

The incremental innovation model (Figure 2) not only illustrates the process of chemical product innovation but also shows the key issues for innovating successfully: the actors' assessment of their core product portfolio strategies, their capabilities in the market and in market-shaping.

COST CONTAINMENT IN INCREMENTAL INNOVATION

OPTIMIZING PORTFOLIO AND RESOURCES

In deciding whether to go forward with any incremental innovation project, it is important for actors to undertake evaluations and have a long-term perspective of the entire product portfolio and sufficient capability to allocate resources within networks. For example, in some of the cases (Cases 1, 2 and 5) in this paper, one incremental project might work for a serious of chemical problems and efficiencies could be gained while innovating for a particular problem or environmental requirement. A cluster of innovation projects for particular areas is a more sufficient way of dealing with projects in a timely fashion, rather than spreading those projects out over years of individual research and development, by which time they may be out of date and have lost competiveness. Combining resources for agreed R&D projects also makes sense.

Another round of evaluation takes place in terms of deciding on the innovation style. A process model is a useful approach to organizing and controlling the various activities involved in the development of a new product, and provides a skeleton around which each project manager can built his/her own path for any R&D project. In the whole process of innovation, actors in networks optimise their product portfolio and decide on a suitable style of innovation so that they can resolve or at least partially resolve the experienced conflicts in producing and exchanging chemicals. A failure to optimize portfolios leads to challenges in long-term business development, sub-optimal use of resources, extended project timeframes and cost escalation.

Therefore, actors need to achieve enterprise visibility for all innovation projects under CMS contracts across their product portfolio and achieve optimal use of resources by getting the right people, on the right stage of the project, at the right time; combine and/or align similar projects; and choose innovation styles to more effectively manage in conflicts, in relation to actors' experience of regulation, technology and cost.

FORECASTING AND INNOVATION AGENDA

The ability to forecast accurately is important for any actors involved in innovation projects, as this optimises resource allocation, cost arrangements, and the project timeline in relation to the technology capability and regulation agendas. This is essential for the planning process of any project and also for the integration between the planners and the technical experts. The ability to enhance visibility and collaboration among the members of a disparate planning team is required in order to streamline the innovation process and make decisions more quickly and accurately, mainly according to cost and practicality. This allows calculative arrangements of material objects and devices. Based on the innovation process, actors are positioned within temporal frames (Araujo and Kjellberg, 2009) in which interactions between entities encourage each project to keep going. For instance, operation leaders will have certain criteria that need to be met, while the finance team, innovation chemists, and regulatory department will seek other objectives. This process will evolve in a socio-technical *agencement* requiring material, textual and other financial investment (Callon and Çalışkan, 2005). Due to the incremental feature of innovation, transparency and visibility among the planning actors makes for fewer errors and a more healthy process.

Through the integration of portfolio management and agenda arrangement capabilities, actors pay more attention to demand forecasting and providing extended actors interactions and collaborations. A major issue of aligning interaction and discussion is creating solid integration and collaboration between those tasked with incremental innovation projects and those executing the projects. Having the ideas and concepts of innovation without rationally evaluating resources and portfolios leads to misinformation and costly mistakes in the later process of innovation. Product development teams (small-groups) in organizations overcome these issues by (1) creating a truly collaborative environment, in which it is easier for the innovation team to share information through certain interactions; (2) ensuring that every one involved in the innovation project has complete visibility of the R&D and execution phase, and is fully aware of the abilities of the technology that is ready in place, and the environmental regulation requirements; and (3) by optimising the available capabilities and allocating all data and resources to make sure everyone in the team is working from the same information at the same time towards the same goal under the CMS contract or the innovation project agreement.

Reducing uncertainties in network

Actors that consistently achieve R&D goals and deliver on the innovation requirements have two practices in common – they carefully make evaluations and effectively assess the innovation risks of projects and, therefore, invest time, resources and technology in successful endeavours that further the company's strategic objectives. Risk assessment should permeate the whole process of innovation, and be manifested as tasks and activities embedded with materialities. Successful innovation project leaders are also very aware that identifying risk is not an intuitive process and that no individual can accurately identify the innumerable contingencies that can, and do, arise. Without assessing these risks and understanding effective collaboration many projects will fail or, at best, encounter large costs through missed deadlines and poor resource and budgetary management in the R&D process. For these reasons, it is extremely important to ensure that capital projects and maintenance investments are used effectively. And technologies exist that provide this assurance. These solutions enable project managers to conduct comprehensive and rigorous risk assessments and provide all involved in the decision-making process –

from those in the field to those in the boardroom – with the information they need to draw sound conclusions.

With an enterprising innovation project and portfolio such as SurChem Solutions had in Case 3, project leaders can collect and analyze the necessary information to successfully manage risk and persuade risk-averse end users through comprehensive test data. In the case of the technology for demulsifiers, those tasked with organizing the right people and the assets they need can successfully manage and complete complex innovation projects. As a result, these project managers and the organizations they serve realized a significant and proven advantage in their efforts to identify, select and execute the best project opportunities through testing 'green chemical kits for demulsification' for their portfolio. In addition, they improved their ability to coordinate existing resources and regulations, to invest in new projects with better performance and comparable cost that further the company's goals, and to establish better solutions in networks.

CONCLUSIONS

This section summarizes the main theoretical and managerial implication of the third empirical study. The research question of this chapter has been:

How do actors adapt to establish incremental innovation in conflicts?

We drew on cases from the perspective of actors' normal business activities in chemical and chemical service development and found that 'adaptive' is the main feature of actors' roles in dealing with the pervasive conflicts they experienced in their networks. As I re-illustrated the cases in a different way, by drawing on actors' adaptive interactions and their consequences from the perspective of relationships, I found that product innovations are undertaken as adaptive activities and interactions, mainly incrementally, driven by CMS contracts and cost issues in either long- or short-term planning.

We developed a theoretical incremental innovation process model based on the cases selected from the oil and gas chemical industry. Many of the insights have been integrated into the five-stage process model presented, i.e. getting the ideas and concepts, portfolio and resources evaluation, establishing R&D, and trial and launch to markets. In the process of incremental innovation, most decisions are made based on a review of experiences and learnings from the markets and past R&D products. There are some implications from the model. One is that the process can be multi-dimensional: it not only shows the process of incremental innovation from decision-making to outcome, but also illustrates how the R&D team are required to contain costs in terms of managing risks, which is more calculable. The second implication is it shows that the interactions of actors can both internal and external to the organization.

Incremental innovation will always be a high-risk undertaking. Managerially, this chapter focuses on small group decisions, providing some guidance for incremental innovation project teams to manage evaluation and costs to decrease risks (combining the capabilities of the innovation project team and executives), and for tasks such as optimizing portfolio and resources, forecasting and agenda setting, and methods to reduce uncertainties across the network.

Although risk assessment and management can never be an exact science, experience and various techniques enable innovation team members to construct risk scenarios and establish where the risks could be, balance long- and short- term planning, and pay attention to forecasting and managing the portfolio to make the costs containable.

Appendix 1: Fieldwork log 1

Date	Type	Place or job title	Company or organization	Duration (min)	Purpose
05/02/2013	Interview	Chemist	ChemSolve	50	Industrial events
05/02/2013	Interview	Chemist	GD Solutions	50	Industrial events
05/02/2013	Interview	General Manager	FAL Specialist	40	
09/04/2013	Observation	SPE risk management workshop	Society of Petroleum Engineers	120	Industrial events, R&D
09/04/2013	Interview	Chemist	FAL Specialist	40	Industrial events, R&D
23/04/2013	Observation	52nd Chemical Stakeholders Forum	DEFRA, REACH	420	Regulatory events, Policy making
23/04/2013	Interview	Chemist	FAL Specialist	60	Regulatory events,
23/04/2013	Interview	Consultant	Independent	60	Regulatory events, technology management
23/04/2013	Interview	General Manager		50	Industrial events, R&D
15/05/2013	Observation	Flow assurance web events	Society of Petroleum Engineers	90	Industrial events, R&D
17/05/2013	Interview	Product Manager	SurChem	40	Industrial events, R&D
19/05/2013	Interview	Consultant	Independent	30	Industrial events, R&D
20/05/2013	Interview	Sustainability Manager	ChemSolve	30	Industrial events, R&D
23/07/2013	Observation	53rd Chemical Stakeholders Forum	DEFRA, REACH	60	Regulatory events, Policy making
23/07/2013	Interview	Chemist	Society of Petroleum Engineers	50	Industrial events, R&D

23/07/2013	Interview	Chemist	Society of Petroleum Engineers	60	Industrial events, R&D

Appendix 2: Fieldwork log 2

Date	Type	Place or job title	Company or organization	Duration(min)	Purpose
30/07/2013	Interview	Chemist	GD Solutions	50	Discussing R&D
30/07/2013	Interview	Product Manager	FAL Specialist	45	Discussing R&D
01/08/2013	Observation	SPE production chemistry and system web workshop	Society of Petroleum Engineers	300	New technology, R&D, incremental innovations
10/08/2013	Interview	Consultant	Independent	50	Discussing R&D
11/08/2013	Interview	Product Manager	NAWO Chemicals (Conflict Case 1)	50	Discussing customers， R&D
03/09/2013	Observation	Offshore Europe 2013 Conference Day 1	Society of Petroleum Engineers	300	New technology, R&D, regulatory discussions
04/09/2013	Observation	Offshore Europe 2013 Conference Day 2	Society of Petroleum Engineers	300	New technology, R&D, regulatory discussions

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