Chemists Who Sell and Chemists Who Don't: Embedding Product Development in Oil Field Services

John Finch* and Susi Geiger**

* University of Aberdeen Business School, Edward Wright Building, Dunbar Street, Aberdeen, AB24 3QY, Scotland, j.h.finch@abdn.ac.uk

** Marketing Group, University College Dublin Business School, Carysfort Avenue, Blackrock Co Dublin, Ireland, susi.geiger@ucd.ie

Competitive paper submitted for consideration to the IMP 2007 Conference

July2007

Chemists Who Sell and Chemists Who Don't: Embedding Product Development in Oil Field Services

Abstract

This paper presents a case study of product development in production chemistry, which is a sector of the upstream petroleum industry concerned broadly with the regular application of chemicals to ensure continuing production from oil and gas fields. Production chemistry companies have a clear science base and offer a hybrid of chemical solutions and services to oil companies. Increasingly, they are also under pressure to innovate in order to demonstrate value to their customers. Product development is a locus previously dominated by science but is now a focal interest of sales personnel. Following recent interest in broadly cognitive, distributed and embedded understandings of both sales (Turley and Geiger, 2006) and innovation (Nightingale, 1998, 2003), this paper locates the question of the early involvement of sales personnel in product development in extended cognition. The paper finds that agents involved in developing the focal company's science/technology activities and its sales activities develop their understandings and articulations of product development with respect to different social settings and with respect to different concepts, artefacts and codes. Any aspirations for the 'early involvement of sales' in product development, particularly under the guise of co-location, should contend with the established social settings of selling and production. Sales personnel have much to offer especially in shaping incremental innovation, but their involvement is not simply a matter of co-location and closer and earlier working relations. Thus, the paper proposes an understanding of product development that is processual and iterative and suggests that the roles of sales and science as well as their interactions in these processes be re-evaluated.

Key words

Product development, industrial sales, extended cognition, science base, upstream petroleum industry

1. Introduction

Product development has long been seen as a solution to a company's quest to secure the conditions of its own continuation. This is the case irrespective of whether product development is contained within a company's organization, or extends to include formal or informal collaboration with customers, suppliers or competitors. It is well established that product development can be enhanced greatly by the early and continuing involvement of sales and marketing personnel, usually because selling implies that sales and marketing personnel know about customers, demand, competition and the end use of products and services (see for example Gupta, Raj and Wilemon, 1986; Griffin and Hauser, 1996). Equally, it is well-established that the uni-directional model of innovation, in which new products are the technological manifestation of basic science, is a misleading and unhelpful representation of product development processes.

Researchers can argue with some confidence that product development should take place in multi-functioning teams, in which sales and marketing personnel have comparable status with scientists and technologists. This oft-replicated and widely accepted finding implies that sales and marketing personnel are otherwise somehow 'naturally' excluded from product development, especially in early phases, and that intervention is required to correct this suboptimal tendency (Bechky, 2003a, b). Sales personnel may be off-site regularly, or at least located away from research and development laboratories or production sites, or may be excluded strategically because of perceived propensities to pour cold water on nascent proposals. It could just be that product development in all its manifestations requires that personnel articulate otherwise personal or tacit understandings and visions, which cannot occur without close working relations, for instance as assisted through co-location.

The above assumes that if only different personnel could articulate their differing understandings of potential products accurately or objectively, product development would be more effective. It is as if sales and marketing personnel can speak for demand, users, consuming and competition, and that scientists/technologists can speak for a firm's productive and scientific capabilities. If such an articulating encounter could take place, the focal company could benefit by means of new products as mediating effectively between as yet unserved wants and as yet unexploited productive capabilities (Tushman, 1977).

Presenting a case study of the development and use of production chemistry in the upstream petroleum industry, this paper proposes a different view of product development, in that the interactions of sales/marketing and science/technology personnel are framed in broadly cognitive terms. The framing brings together recent conceptual and empirical research in innovation studies (Nightingale, 1998, 2003; Hellström, 2004) and in sales (Turley and Geiger, 2006), which propose that cognition be understood as embedded, situated or extended, rather than in mentalist and individualist terms. Extended cognition differs from mentalist understandings in that humans articulate and represent plans and proposals with and through concepts, codes and artefacts that are close-at-hand and so constitutive and re-constitutive of contexts (Håkanson, 2007). Mentalist understandings, by contrast, anticipate that individual agents imagine new products through their own volition and in personal and idiosyncratic ways, and hence with a uniquely personal understanding of context or situation, before articulating and sharing their meanings in a social setting.

Following extended cognition, descriptions and reasoning in support of new products are made through direct and simultaneous involvement of concepts, codes

and artefacts. The tools and the cognitions they generate are immediately analogical, connective and social and so do not pre-exist their public or social articulation in a mentalist or highly personal state. This implies that the tools shape product development directly, rather than indirectly as communication tools. Understanding product development as generated through extended cognition still anticipates that its processes can be improved through regular communication and interaction between technologists and sales or marketing personnel. However, the interaction process, conceived as extended cognition, *is* where development takes place, rather than being the articulation and amalgamation of previously established personal and tacit visions of new products.

Extended cognition prepares researchers and product developers for a radically different understanding of interaction in which products are understood as being shaped in a setting that is necessarily social and includes tools and artefacts. So, critically, the analytical focus extends to the theories, concepts, tools, formula and other means of formulation and articulation that are close-at-hand in the contexts of product development, and also to how product development came to be located in particular contexts. In other words, innovation, such as product development, concerns coping with combinations and re-combinations (Nightingale 1998). An extended cognitive approach to innovation invites researchers to consider how many agents, including sales personnel and the tools and concepts they employ, can develop roles in articulating a new product and the problems it will address.

The following section explains how understanding product development as an instance of extended cognition provides a novel perspective on the interactions and encounters between science and technology personnel and their sales and marketing colleagues. Section Three presents the case study centring on the activities of a UK-based production chemistry company. Section Four draws out the practical and conceptual implications for understanding the encounters of science and technology with sales and marketing as instances of extended cognition and articulating instead of a designed arena for articulating otherwise tacit and personal knowledge. Section Five concludes.

2. Sales-Science Interactions and New Product Development

Research into the critical success factors in new product development has long established that the early involvement of sales and marketing is important. If this is so obvious and so well verified, researchers may either respond with a, ‘if it is so obvious how can instances of non-compliance ever be found?’ More pressingly, researchers may respond with, ‘if it is so obvious, and sales and marketing are working in product development from early stages, surely things cannot go so smoothly, given the radically different bases in skills and experience?’ The basis of this paper is that the question of sales involvement with technologists and scientists is far from resolved by multi-functioning teams.

This section seeks to redefine the problem of sales and product development away from the empirical concern with co-located, multi-functioning teams and the early involvement of sales and marketing personnel therein to consider what such interaction can achieve and how it might be achieved. In order to do so, the section frames the question broadly in terms of extended cognition. Extended cognition draws researchers’ attention to how agents calculate and communicate through the use of tools and in so doing, shape understandings of what new products should look like,

how they should function and for whom, in advance of their development as prototypes and in tests. As is common with virtually all recent research in product development, this section rejects the fabled uni-directional model where science is the basis of new developments that are subsequently handed over to sales and marketing for commercialisation (Nightingale 1998). In so doing, it rejects the simplistic but coherent role of sales as a down-stream commercialising agent and so poses the question of how sales personnel become involved in the early formulation of new products as solutions to (others') problems. Crucially, it raises the question of how sales and technology (or science) personnel may interact: what might the conversations sound like, given that the functional specialisms imply radically different expertise, artefacts, training and mundane experiences? The section ends with a consideration of product development being identified with an interface between sales (or marketing) and technology (or science), and so also marking a significant boundary that may have little direct bearing as a locus of activity on the established structural concerns with corporate boundaries (Araujo et al., 2003).

2.1 If Firms Need Product Development, Do Science and Sales Personnel?

Product development requires a complex extended theory of cognition because it disrupts established action networks, including the bases of making calculations (Callon and Muniesa, 2005). Viewed in calculating terms, Schumpeterian entrepreneurship is usually presented as requiring a non-rational discontinuity or break from the action network pertaining to established products.[1] Any talk of 'breaks' is odd because those involved in developing new products seem often to cope quite well and companies, and networks of companies, seem to maintain a sense or expectation of continuation. The question of this paper pertains to how agents produce and maintain continuity in the face of Schumpeter's proposed destructions, which extend to activity networks, and to discontinuities in calculation. It is in these areas where extended cognition can be investigated as a way of coping with continuation in uncertainty and also as a means of articulating among actors who draw on different experiences and relationships during product development.

In order to understand new product development, we need to grasp the understandings of this activity of the individual actors involved. This section develops from the assertion that firms undertake new product development, with an important reason being as a means of competition. So far, we have implied that the firm has interests in product development that are shared among its personnel. If greater sense can be made of different conceptions of product development once the uni-directional model is forgotten, extended cognition allows us to make a much more radical claim about product development than is possible in the empirical research projects that drew attention to the joint endeavour as a critical success factor for the firm.

The implication of extended cognition is that new product development is innovative and involves research and development as – potentially at least – activities shared across different actors, such as scientists, sales people and product or service users. Is it only the possibility of interaction across professional disciplines or roles that promotes product development? There may well be benefits from specialization in product development, but these do not map well onto professional identities such as science or technology, or sales or marketing. Do the activities of selling and of science/technology need new products in the same sense that the firm itself does? In isolation, do sales and marketing personnel articulate different (incompatible?) versions of product development compared with colleagues in science or technology?

If there is an identity of sales and technology activities with the firm's continuation, it is in their interaction, which is the broad propositional basis of this section.

So what can we expect from sales and marketing in product development? Obviously not selling because the product is being articulated, developed in prototype, tested and adapted (Henderson, 1995, 1998). It is not ready for selling yet. So the involvement of sales and marketing personnel in product development has something instead to do with them being able to speak on behalf of the new product's potential users. The challenge for sales and marketing personnel is to articulate, for instance by analogy, something that does not exist based on what does exist (perhaps offered by rival firms), or on what customers, clients or users say that they would like, or otherwise seem to need but do not yet have. And articulation through extended cognition is generated in a network of concepts, codes and artefacts, which is often unique to sales and marketing – such as the concept of value discussed below.

Similarly, it is not obvious once we leave behind the uni-directional model that those involved in science, for instance through training and professional allegiance and identity, should be interested in product development (as a manifestation of technology). The heuristic of science is in proposing new findings and in assessing the validity of such findings. There is no necessary momentum in this science heuristic that continues towards commercialisation beyond assessment to specific applications in the form of technology. For example, science can draw upon experiments that isolate proposed causes, but technology also copes with interactions and combinations of elements, materials and users in different settings. Not only are science and technology different heuristics, but isolation and combination are different activities. So scientists doing science are not easily connected with product development.

New products are manifestations of innovation, which firms require for their continuation. Reasons have been presented as to why personnel with roles in sales and in science are not expected to participate in a joint endeavour that could be called 'product development'. Established research argues that sales and marketing personnel should be involved from an early stage, implying that science or technology personnel are 'naturally' the originators of new products. Yet, science and sales and marketing are radically different heuristics, neither of which seem overly well suited to developing new products. Both have useful experience in articulating what new products can look like, and especially in developing new products once some clear visions have been described. Expecting scientists and sales personnel should talk regularly is not that revealing of how they should talk, and about what, given these discrepancies. Each specialism, each mundane conversation, has its own extended cognition, shaped by cognitive tools (such as IT software or science labs), theories, artefacts, processes, prototypes, and regular discussions (Hutchins, 1995; Suchman, 1987, 2005). The innovation heuristic is identifying and articulating a stable end point in the form of a new product, but how actors arrive at this stable end point in their interactions remains contested. The following case will examine this question in more detail.

3. The Case: Product Development in Production Chemistry

This paper's focal company, referred to as Subchem, faces the fundamental business problem of deciding how much innovation it should be undertaking, how much product development it should be doing, and how interactions between sales and

science should be shaped in these processes. This section draws upon the case study to explain why it is so difficult for all actors involved, or potentially involved, to determine how much innovation, how much product development and through what interactions. Nevertheless, product development occurs regularly and is recorded in Subchem's products database. This section highlights the roles of Subchem's science personnel and its sales personnel in undertaking product development, and in contributing to the resolution of 'how much'.

Subchem has an extensive science base (which also undertakes testing for sales activities in other countries), competes in the UK with five other production chemistry companies, offers a complex hybrid of product and service, and produces for a range of customers with varying knowledge and appreciation of production chemistry. It employs around 90 people, of whom around 25 work in or in support of sales and around 30 work in technical services. Most sales people had previously worked as chemists, undertaking lab work and field trials. Many employees have chemistry degrees, with recent recruits also having postgraduate qualifications in chemistry. Subchem is part of larger chemicals group, which gives it access to fundamental (molecular) chemistry research. It also operates in all the upstream exploration and production locations world wide, although this paper concentrates on its UK activities. The majority of its sales in the UK are with one major oil company, and an even larger proportion of its sales are conducted through medium term chemical management service contracts, which are put out to tender every four or five years by the major oil companies and also by the larger independent oil companies.

Subchem offers a complex of chemicals products and service (Araujo and Spring, 2006). The products include demulsifiers (that separate oil and water), corrosion treatments, scale treatments, biocides, and treatments which inhibit the accumulation of waxes and other deposits. The service aspect is vital, and includes regular testing and monitoring of products in use, diagnoses, recommendations for new products and logistics to arrange for the timely delivery of the related products and services.

Demonstrating an innovative capacity is a vital dimension in the tendering processes for Chemicals Management Service (CMS) contracts, and demonstrating product development forms part of most customers' performance reviews for established contracts. But judging or calculating how much innovation, or how much product development, appears to be incredibly difficult, especially where it is not clear to all involved that customers are capable of valuing and evaluating the benefits of product development. Occasionally, competitions occur between production chemicals companies where one company 'challenges another's chemistry' with respect to a single product, allowing customers to makes sense of product development at least as manifest in one type of product.

As a medium sized industrial firm, Subchem does not have specific marketing capabilities. Sales people or account managers take on the role of marketers, speaking on behalf of and to customers. Rather than being conceived of as a unit for research and development, Subchem's technology group is reminiscent of a basic science laboratory, charged specifically with recommending and testing chemicals for suitability and from which product development regularly emerges. Thus, the interface in this case is a specific, industrial incarnation – perhaps even prototypical – of the general interface between marketing and R&D.

3.1 Methodology

The research method is the case study method (Yin, 1994). A single case design was chosen to provide 'richness' of empirical illustrations and findings (Weick, 2007). According to Siggelkow (2007), conducting a single case study of organisations can be a valuable research approach in three distinct situations, namely for purposes of motivation, inspiration, and illustration. Ours is an inspirational use of the single case, consistent with an aspiration of inductive theory generation (Eisenhardt, 1989; Eisenhardt and Graebner, 2007; Easton, 1995). While existing theories of innovation and multi-functional teams in product development are abundant, most of these are based on consumer goods manufacturers, or else, in the case of business-to-business networks, on a limited understanding of the interactions, ruptures and tensions of multi-functional teams. Thus, this paper sets out to explore the 'how and why' (Edmondson and McManus, 2007) of extended cognition manifest as product development and technology at the intersection of sales and science through a grounded investigation of a single case company. The final objective is to develop theoretical insight regarding the processes of product development particularly in industrial settings.

Subchem was chosen for the frequency and indeed ubiquity of product development in a broad sense (standard products feature only as a small proportion of the overall value offer to clients), the clear distinction across its science base and industrial selling, and for ease of access (Eisenhardt and Graebner, 2007). Subchem was first approached in late 2005 and first site visits conducted in early 2006. It soon became clear that instances of product development abounded and that there were tensions between the sales and science groups in how these instances became articulated and negotiated. Given the profusion of innovative instances, as defined by a projects database, it was decided that it would best to utilise a theoretical sampling of innovative products/processes (Glaser and Strauss, 1967). This was carried out with the help of Subchem's projects database capturing all product development processes and corresponding outcomes (products developed, if any, or otherwise) from 2003 to present. The database revealed not only a history of the product development, but also key personnel involved in the individual process from the science department, from manufacturing, from sales and from the client side.

Theoretical sampling of cases (processes/products) within-the-case was conducted on two grounds: a maximally diverse range of clients, covering both contract and non-contract clients as well as smaller and bigger operators in the oil industry, and a range of perceived complexity/standardisation of the product development process. Six cases of product development were chosen for sampling; key personnel of these cases were subsequently contacted and interviewed. During 2006, 19 in-depth interviews were conducted of about one hour each. Ten of these interviews were directly case-related and nine further were with senior managers covering their involvement in the individual cases as well as general discussions of coordination between the science group, sales and manufacturing. The interviews that focussed on particular cases were conducted by one researcher and all but two of the interviews with senior managers were undertaken by both researchers. Most interviews were recorded, transcribed and analyzed using QSR NVivo software, with five others being transcribed from detailed notes soon after the interview. In addition, database entries for each project case were analysed, and email exchanges and tender documents were examined.

The research moved into a second phase in late 2006 when the researchers also met with personnel at two of Subchem's most important customers. In both instances,

quarterly performance review meetings were attended by one of the researchers, followed by meetings with the customer's lead buyer and lead chemist.

Together, the range of data provides a rich insight into what could be analysed as the company's three different modes of interaction between sales and technology groups in product development, identified as: routine business, continuous innovation and radical innovation (see Table 1), which are explicated below. After a review meeting with one of the senior managers (also the researchers' main point of contact at Subchem) in which the three modes of interaction were presented, one further case was explored to complete the researchers' theoretical understanding and a feedback meeting was conducted with representatives of sales and science teams, which led to further refinement of the analytical distinctions.

-----INSERT TABLE 1 ABOUT HERE--------

3.2 Three Categories of Interactions between Sales and Technology in Subchem

3.2.1 Routine Business

Routine business is something of a residual activity for Subchem in that it involves something like repeat prescriptions, given the regular normal monitoring of established products in use. The part of Subchem's business that fitted the research category of routine business occurred within established Chemical Management Service (CMS) contracts lasting between three and five years. However, the activities within CMSs cannot be reduced ex ante to a set of routines and practices because development plans are integral to Subchem's relationships with its customers, are written into its contracts, and form part of its regular performance reviews. As such, routine business, considered 'in the round', can only be recognized in an ex post sense, in which product development proved unnecessary. This raises the question of why product development proved to be unnecessary; hence the residual status of the category of routine business.

Routines and routine practices in the micro-sense contribute to the reproduction and stability of Subchem's structure and its business processes, but the category "routine business", writ large as the focus of this subsection, can perhaps over-do stability. Ultimately it makes only some use of Subchem's science base and is of limited value to their customers, hence of little strategic value to the company commercially speaking. As researchers, we noted that there were standard operating routines and that these sometimes manifested themselves in something akin to repeat prescriptions as potentially the firm's normal activity. Our key informant at Subchem placed a different interpretation on the category of 'routine business'. He saw the second category – increment innovation (discussed below) – as Subchem's normal activity. In this sense, routine business could represent a sense of failure for Subchem, of questioning why no product development took place in that project. Of why Subchem failed to develop manifestations of its innovative capacity that could be demonstrated to the customer, and what roles sales and technology groups have in these stabilising, rather than innovating activities.

Considering routines and routine practices first, Subchem, like many businesses, has a highly codified system of standard operating procedures. These are arranged around a collection of databases, including for projects and products. At any one time, Subchem has hundreds of live projects on a database and thousands of current products. Some projects last for a matter of weeks and some, exceptionally,

continue for two or three years. A project is usually initiated by someone in sales as a request for monitoring or a retest of an established product to a colleague in the technology group. The request is formalized as an entry on the projects database. The project is then investigated by a member of one of the technology group's personnel, with tests being scheduled and undertaken. Technology personnel will select from a number of standard tests, which are shaped by standard testing equipment, such as ovens, refrigerators and immersion tanks.

Projects usually involve interpretations of a problem described in the request, testing for alternative solutions and writing a short scientific report in support of a recommendation. A project is closed once the recommendation is accepted in sales, although the database also requires a short feedback form to be completed, which provides an opportunity for someone in sales to describe the customer's use of the product associated with the technical recommendation. It is possible (though rare) for a project to be completed with only email communication between sales and technology personnel mediated through the projects database. Sales personnel may be embedded in a customer's premises and organization and in any case sales and technical personnel are in neighbouring sites, rather than being co-located. Thus, physical distance often promotes the extensive use of the database and interaction tool in this category.

Timing is critical and scheduling lab time is an area of contention. Sales personnel need tests to be performed so that recommendations can be given to clients. Technology personnel need to receive samples of oil (or gas) from the field quickly as aged samples are less reliable. Interviews with science personnel showed they knew which tests to perform. While all activities draw upon routines in the form of standard operating procedures and normal practices, which were tied closely with and mediated through the projects database, routine business became realized (and so identifiable to the researchers) by repeat recommendations. Tests produced results that demonstrated to sales personnel and to customers that no change was required (for instance in Case 1 in Table 2). For routine business to emerge from the routine practices and standard operating procedures, opportunities for product development have not been pursued. While this may seem to be a desired – because stable – outcome for the technology group, in these cases sales have failed to demonstrate an important concept to their customers, namely that of 'adding value' (see below).

-------INSERT TABLE 2 ABOUT HERE--------

3.3.2 Incremental Product Development

Subchem undertook incremental product development through four kinds of processes: (1) An interviewee described each oil field as having a chemical regime, which could change through the field's continuing production and hence maturity (Cases 1, 2 and 4); (2) Subchem devoted a great deal of attention to changes in environmental regulations, which required the phasing out of some chemicals and hence of some products to which 'substitution orders' were attached (Cases 2 and 3); (3) Sales personnel, usually in collaboration with customers, identified some Subchem products that could be 'changed out'(Cases 2 and 4); and (4) Production chemistry companies can instigate phases of competition by 'challenging one another's chemistry', pertaining to particular products (Case 1). Case 5 is unusual in that it involves a member of the technology being part of a marketing activity at an international trade fair.

To briefly discuss the interaction between sales and science teams in each case, oil and gas fields and their associated production facilities are unique and from Subchem's perspective can be described as presenting a particular chemistry regime. In geological terms, oil reservoirs have unique geological formations and constitutions. Case 1 refers to an oil field that had recently begun production, but the production infrastructure was exposed to barium sulphate through the barium in the 'produced water' that had accumulated alongside the oil in the geological reservoir. Such problems tend to intensify as more and more of the hydrocarbons are produced because the 'water cut' increases relative to the recovered oil. With high oil and gas prices, it pays oil companies to develop means of intervening to enhance production, such as re-injecting produced water into a reservoir so that its pressure is maintained. This results in even higher proportions of produced water being re-circulated. Environmental legislation which regulates the disposal of produced water further enhances the attractiveness of re-injecting. Through regular testing, the need for adjusting prescriptions as the chemical regime at a production installation changes can be detected. Testing either leads to routine prescriptions as in Case 1 or incremental product development and an adjustment of the prescription to the changing production environment.

Cases 2 and 3 were both driven by the need for the customer and Subchem to "change out" a product supplied by Subchem, which had a substitution notice on it with respect to environmental regulation.[2] With Case 3, environmental legislation was a major impetus to incremental product development and provided significant opportunities for Subchem to bring together its knowledge of environmental regulation with its ability to develop products from chemical bases developed by researchers in the chemistry labs of its parent company. The chemical bases included innovative molecular chemistry such as inserting oxygen molecules which enabled chemicals to break up and disperse rather than accumulate. Typically, these cases were driven by the technology group but had to be developed in close interaction with the customers, as represented through the sales team.

As an example of the reverse scenario, Case 5 exhibits how sales and marketing can lead product development. Subchem's global marketing manager in Houston argued that Subchem seemed to be lacking a range of products for use in deepwater, which is a significant and now mainstream production activity in the US Gulf of Mexico, as well as West Africa. He proposed that a range be presented at trade fairs in 2005, and identified that Subchem's chemistry group in the UK should lead this project, given its pre-eminent status. As mixes of chemical solutions, the products existed in nascent form. But to become deepwater products that could be presented at trade shows and sold to oil companies, the products had to be calibrated and authenticated through testing. A sample range of existing products were selected to form the deepwater range, and were tested in conditions that synthesised deepwater conditions, and also with respect to US environmental regulations. The purpose of the marketing effort was really aimed at proving to oil companies that Subchem understood the demands of deepwater production and had the technical capacity to develop products that would operate effectively in these more challenging conditions. As a consequence, Subchem had to acquire new testing equipment and have this verified, representing a considerable disruption to the technology group and a rare and seemingly uncomfortable case of 'marketing activity' to the sales group, who usually act upon much more familiar requirements of individual clients.

'I challenge your chemistry' is an iconic motif of the sales perspective of this paper's research project and is exemplified through Case 1. Like many duals, there

are accepted rules of conduct and process. Sales personnel who issue a challenge know what they are letting themselves and their company in for, and what demands they will be making of rival companies and also a particular customer. Challenging another's chemistry makes sense in the context of the CMS contracts prevailing in the industry. Oil companies do not want to isolate themselves from the broad field of production chemistry as a consequence of selecting a particular tender submission. When Subchem is awarded a CMS contract (as with Case 1), it still has to supply what then become third party chemicals from other production chemists, many of which are a legacy from previous CMSs. Subchem can enjoy profit margins of 30 to 40 percent on its own products, where it can charge typically a five percent handling fee in delivering the incumbent products supplied by third parties. So Subchem has a development plan to 'change out' the third party products with its own. This is a main target of sales personnel in their roles as account managers and is again closely related to demonstrating superior 'value' to customers.

At the same time, other product chemistry companies can approach oil companies with proposals for new products even when they do not hold a CMS. This is regarded to be the most challenging dimension of new business development for sales personnel, of instigating a chemicals challenge and so developing new business, or defending their own business in case of a competitor's chemical challenge.

In both routes – change out when taking over a CMS and issuing a chemistry challenge as an outsider – sales personnel have to overcome the risk aversion of an oil company's field manager, perhaps extending to a more senior business unit manager. These are unlikely to be chemists. Oil companies contract out production chemistry and usually retain one or two senior chemists. Introducing new chemicals is a risk and can put at risk field managers' prospects of achieving production targets. The risk can be militated against by Subchem's sales personnel working closely with the oil company's senior production chemists, such that professional bonds can overlay the strong commercial imperatives. Further, chemical challenges are usually refereed by one or two widely-regarded independent chemistry labs, which provide independent adjudications as to each product's characteristics.

To summarise this subsection, incremental innovation draws attention to the very active role of customers – and by implication sales personnel – in shaping product development in production chemistry. In all cases, Subchem's sales personnel have to persuade customers of the validity of new and improved products, for instance by arranging lab tests and then field trials. Customers have different needs for and understandings of production chemistry and sales personnel have to take on an active role in guiding incremental innovation. By contrast, most cases of incremental innovation will be piped into the technology group by the same standard operating procedures that are also prevalent in routine business. Thus, where in cases of incremental innovation sales have an acute understanding of product development requirements, technology personnel may perceive both categories (routine business and incremental innovations) through the same concepts, tools and artefacts (such as lab time scheduled or test to be conducted).

3.3.3 Radical Innovation and Product Development

One of the cases identified from Subchem's projects database (Case 6 in Table 2) is an instance of radical innovation. The product is a means of releasing chemicals slowly through embedding them in reservoirs rather than continually injecting chemicals through tubing, with accompanying adaptations to the chemicals so that they can tolerate being released slowly in situ. The chemistry group has hosted this

episode of product development and has been able to section off a proportion of funds, space and the time of a senior chemist. The project has led to a family of products which have performed very well in field trials and have attracted considerable interest among oil companies in which to host the trials. The product is appealing in principle because it 'piggy-backs' on other necessary interventions in reservoirs, such as fracturing, and so reduces the need for additional interventions to deliver chemicals.

From a selling perspective, the innovative product has proven problematic. Production chemicals companies have property points of access in most production infrastructure because the tubing is built in to deliver chemicals. And technical and sales personnel are welcome on production installations to supervise the application of chemicals and to oversee or undertake field trials. The innovative product does not use these built-in facilities, but rather relies on 'piggy-backing' activities undertaken by other companies. These other companies just happen to be much larger trans-national service companies that offer a wide range of technologies such as well development. Consequently, Subchem can only deliver its product in collaboration with the larger and more powerful service company, with which it has signed a marketing and sales agreement. Furthermore, Subchem produces its products at its UK site, usually by combining different chemicals bases. The chemical bases are designed at the parent organization's lab, but mixing and logistics are undertaken in the UK. Product manufacture and logistics are aligned with the conventional means of application. The innovative product's novelty is in its radically different means of delivering and releasing chemicals within reservoirs. Subchem has no capability in manufacturing these media, and has experienced difficulty in persuading other companies to undertake production in anything other than test batches. While this case is an instance of successful innovation as understood by the technology group, it caused significant disruption to standard sales processes to an extent where the new product's value for the firm is questioned by sales and manufacturing personnel.

4. Analysis: Articulating Product Development through Concepts, Artefacts and Codes of Extended Cognition

Subchem faces a dilemma over how best develop and exploit its science base. Each of our cases provides perspectives on Subchem's normal routines and practices and activities in product development. Its sales personnel are tasked with creating new business, which can include anything from updating its own offering as supplied to particular oil companies, to issuing chemical challenges, to assembling tenders for CMS contracts. The chemistry group practices chemistry as a technology informed by science in whichever context is required and mostly in connection with standard operating procedures, with the rare exception of cases of radical innovation. The dominant operating procedures fit most closely with the residual case of routine business, but shape and are also tested regularly by incremental product development, ands as such as impose 'limits to inquiry' and bases of 'intelligent adaptation' (Flaherty, 2000). Sales experience less routine business as most of their activities are guided by customers' concerns with 'value' and corresponding performance measures, prompting sales personnel to seek out and support innovative activities.

Analytically, the case of Subchem raises the critical question with respect to the discussion in Section 2 (above): Which tools, concepts and codes do Subchem's technology and sales personnel draw upon in articulating product development?

Empirically, applications and assessments of the concept of extended cognition are difficult to present. Extended cognition is after all a high-level philosophical critique and development of mentalist cognition and also relies on counter-factual arguments. Anthropological research projects into situated cognition, such as Hutchins (1995), rely on researcher observations of actors using concepts, codes and artefacts. Our approach in this section is to highlight where concepts, codes and artefacts have been drawn upon in connection with product development. Value is an important concept across Subchem's science base, its selling and its customers. Codes are shared by scientists and sales personnel and by customers, as written into Subchem's database and into those customers that use performance scorecards. Artefacts include the database, the testing equipment in the lab, samples from oil and gas fields, and scorecards.

4.1 Concepts of Extended Cognition – Value

Extended cognition prepares researchers to understand social contexts as comprising concepts, codes and artefacts. Subchem's sales personnel are in continual interaction with customers, especially where relationships centre on CMS contracts, and with potential customers. In some cases, sales personnel are located at customers' premises. Sales personnel continually encounter 'value' as a dominant concept. Sales personnel are expected to create value for their own company and also for customers.

Value is a notoriously difficult and subjective concept to make operational. In industrial settings, where a few significant relationships have the multiple dimensions of contractual obligation, means of exchange, resource, means of communication, and potentially a source of a large and indivisible amount of business in the future, simple measures as articulations are instable and incomplete. In the second phase of this research, we instigated informal and open-ended meetings of just over an hour to include our key informant at Subchem and a couple of representatives from a customer. In both meetings, the customer representatives covered technical chemistry and commercial roles. The question of value was prominent in both meetings. In one meeting, participants commented that they rarely had opportunities to discuss the matter, just assuming that it was articulated reasonably well in contracts. In Section 2, we argued that concepts were one tool by which new products could be articulated within extended cognition.

Subchem's sales personnel need to demonstrate value to customers, but the following excerpt from a meeting (of February 2007) shows that Subchem and its customer have differing views about value, and how this changes, and also have different ways of articulating value as a concept (Oil 1 is the customer's contracts manager, Oil 2 is the customer's lead production chemist and SC is the key informant at Subchem):

Oil 1: Yes. But that's where it comes back to identifying your drivers, so there are some drivers that you just think, 'that's not quite so important but these are key to us' so yes.

Oil 2: What's our biggest driver just now? [For us]. Chemistry. What's the biggest driver [for us]?

Oil 1: Well we're always driving oil, up-time, but it's a combination of oil and [also] water legislation, calcium nathinate we mentioned, and basically scale

management basically is big here because we need to keep all the wells flowing every day…

Oil 2: Keep the oil flowing.

SC: See, my biggest driver, rather than selling more, my biggest driver would be to increase my margin and if I could do that and sell less the organisation would be delighted with that.

Oil 2: Then I suppose what we're trying to then say is how can we then explore doing that? Because I don't know how you would arrive at that situation because it sounds as though you would need to sell more to [us] in order to get it to cost less. So how would you increase your margin?

SC: To increase margin we have to look into the efficiency of products, maybe new technology but also looking at some sort of innovation, innovation perhaps. So that if there's additional value being created for [you], perhaps we could share a little bit of that.

Oil 2: [We're] reasonably receptive to that, yes.

The excerpt shows each speaker explaining the concept of value through situating it and themselves in typical business scenarios. Production chemistry allows the customer to continue its production of oil while satisfying environmental regulations. Subchem's manager is keen to take the conversation forward and bring the company's innovative capacity to the fore. The conversation indicated a close working relationship between the companies, but even so the discussion only begins to probe the possibilities of working together to consider 'additional value being created', and whatever this means for product development activities. The concept of value is useful in this conversation to demonstrate among the speakers that they both share the concept and also express it differently. The technology group often misses out on this formulation of the concept of value, notwithstanding the fact that indirectly, it will guide its activities with regard to this customer.

4.2 Artefacts of Extended Cognition: Performance Scorecards and the Chemistry Laboratory

The concept of value is such a crucial one for Subchem's customers and salespeople that scorecards and key performance indicators (KPIs) are designed by some of Subchem's customers to materialise and stabilise the concept of value. They are used in business meetings and quarterly reviews to evaluate the key sales personnel as well as the company as a whole. Again, members of the technology group are absent from these meetings, so only experience this representation of value second-hand as a potential shaping force of their activities. Sales personnel, on the other hand, have to justify both routine business and the different types of innovation in relation to points on their performance scorecard. For sales personnel, the central question in any development endeavour will be: Can this product create value for my customers? And if it can, how can this value be best communicated and demonstrated? Products are shaped through the value concept and its articulation through KPIs; they are, for sales people and customers, value materialised, utilising the buyer-seller relationships as a conduit for extended cognition.

While sales personnel are driven by the artefacts of KPIs and scorecards, technology personnel work with an array of artefacts in Subchem's lab that shape their cognitions. These include samples of oil taken from producing oil fields, synthesized samples of produced water, samples of chemical bases from which Subchem's products can be reproduced at experimental scale, testing equipment, some of which is developed on site and some of which requires external validation. Sales personnel frequently visit the technology group's office complex adjacent to the lab, but rarely visit the lab itself. In contrast some customers spend time in the labs, especially in conducting monitoring exercises. Indeed, the lab seemed to be a quiet place in which chemists set up and revisit experiments to monitor progress. The lab is where the requests for tests, received through the database or other communication with sales personnel, are materialised and products subsequently formulated. In comparison to the apparently volatile world of the sales group, the lab appears to be dominated by a greater degree of stability and predictability.

4.3 The Projects Database – A Code of Extended Cognition

While the concept of customer value and the artefacts that the laboratory equipment or KPIs represent shape product development in a rather loose manner, the projects database exemplifies a narrower framing of extended cognition in the form of a code, shaping interaction between the groups directly and openly. The projects database thus represents an interesting 'trading zone' (Kellogg, Orlikowski and Yates, 2006) between sales and technology. Sales personnel provide the impetus for most entries that are classified according to customer importance, business risk and projected commercial value. Thus, the envisaged product as the outcome of the project trajectory is first framed by value concepts through the perspective of the salespeople. There is however a disconnect between the codified version of value, as expressed in the database, and the concepts of value encountered in customer interactions or through KPIs. The database, as a means of communication and 'trading zone', necessarily simplifies these concepts and artefacts. Thus, through the database the technology group encounter a much diluted version of the end point of product development than that originally framed in the customer-sales interaction. It then proceeds to carry out the project (one or several laboratory tests) that will lead to a product outcome, thus shaping the envisaged product's embodiment through their laboratory equipment. They will however have to use the database to communicate what has been done, why, and at what cost, back to the commercial side of Subchem, in keeping with the codes the database imposes on this communication. In this instance, the project database represents a highly codified zone of translation between envisagement and embodiment of innovation (Star and Griesemer, 1989).

4.4 Summary of the Analysis

Håkanson's (2007) discussion of articulating involving concepts, artefacts and codes draws on combinations of ways of generating communications and understandings, the crucial point being that the dimensions interact and come together generatively. Our subheadings in this section refer to the generation of new products through situated cognition, but the incidents do not connect together seamlessly. Customers struggle to form judgements with respect to value because chemicals and laboratory equipment are used in a number of heterogeneous settings. The occasional chemical challenge provides another fleeting and situated comparison of different companies' offerings specific to that challenge's setting. Salespeople struggle to articulate value as the prime means of doing so is through the projects database, which allows projects

to be ranked by taking into account highly codified measures such as the customer, the likely sales and the estimated chances of success for a resulting product. Similarly, chemists match expectations of value, as coded in the projects database, with experiments which set up and then select recommendations among alternative solutions.

5. Implications and Conclusions

This paper's premise is a recasting of the established empirical finding, of the early involvement of sales and marketing in product development being a key success factor, within the framing of extended or situated cognition. Spatial proximity alone presumes that product development is improved through regular and informal communication. Extended cognition allows researchers to assess how communication can take place where expertise and experience is intertwined and manifest with particular tools, including concepts, artefacts and codes. Product development benefits from specialization in training, experience and practice, but is itself a generative and interactive activity in which actors – especially sales and science personnel in Subchem's industrial setting – articulate new products through different tools. At Subchem, chemists understand the concept of value and perform product development in close connection with their testing and experimenting apparatus and receive messages formatted or coded through a database, reinforced through telephone and face-to-face conversations. Sales personnel are in many cases located at customers' premises and understand the concept of value through artefacts such as scorecards in connection with performance reviews, and as claims written into tendering documents.

The implication is that co-location of itself is a misleading inference when seeking improved performance in product development. For instance, Subchem contributes to many locations, including the basic science of the labs of its parent company, its chemistry labs, its operations location, the on-shore locations including those of customers where sales and accounts personnel work, and the off-shore production installations where its products are being used and where field trials are conducted.

Similarly, an argument that all tools (concepts, artefacts and codes) should be shared and interaction increased is invalid. Extended cognition extends from individuals' training, experience and situated practices. Where tools are shared, their meaning and significance is developed through connections with other tools, which in combination are unique to each actor. For instance, most of Subchem's sales personnel began their careers as chemists undertaking tests and experiments in labs and in field trials (so are close to chemistry) and also work regularly with customers who in most cases are not chemists. The combination of expertises will lead to unique understandings and thus inherent disruptions with technology personnel, who in turn have their shared history with many salespeople but now also interact in highly specific professional networks,

In conclusion, the framing of extended cognition raises the question of how different groups develop products through interactions in related and significant settings. Sales and accounts personnel develop representations of chemistry labs often through reflecting upon their earlier career experience working there. Similarly, sales and accounts personnel have regular contacts with customers' worlds; sometimes being active participants at customers' sites. Chemists represent the worlds of their colleagues in sales and of customers mainly through samples and

testing and experimenting apparatus, for instance in synthesizing produced water and mixing this with oil samples in order to test demulsifying products. Co-location may be a means to address the problem of bringing meaningful representations of customers' worlds into the lab, but representations will always be generated through tools of articulation such as those discussed above.

References

Araujo, Luis, Dubois, Anna and Gadde, Lars-Erik, 2003, The multiple boundaries of the organization, *Journal of Management Studies*, 40, 5, 1255-77.

Araujo, Luis and Spring, Martin, 2006, Services, products and the institutional structure of production, *Industrial Marketing Management*, 35, 797-805.

Bechky, Beth A., 2003a, Object lessons: Workplace artifacts as representations of occupational jurisdictions, *American Journal of Sociology*, 109, 3, 720-52.

Bechky, Beth A., 2003b, Sharing meaning across occupational communities: The transformation of understanding on a production floor, *Organization Science*, 14, 3, 312-30.

Callon, Michel and Muniesa, Fabian, 2005, Economic markets as calculative collective devices, *Organization Studies*, 26, 8, 1229-50.

Easton, Geoffrey, 1995, Methodology in industrial networks, In K. Möller and D. Wilson (eds), *Business Marketing: An Interaction and Network Perspective*, pp. 411-492.

Edmondson, A. C. and S. E. McManus, 2007, Methodological fit in organizational field research, *Academy of Management Review*, in press.

Eisenhardt, Kathleen M., 1989, Building theories from case study research, *Academy of Management Review*, 16, 620-627.

Eisenhardt, Kathleen M. and Melissa E. Graebner, 2007, Theory building from cases: Opportunities and challenges, *Academy of Management Journal* 50, 1, 25-32.

Flaherty, M. Thérèse, 2000, Limited inquiry and intelligent adaptation in semiconductor manufacturing, in Dosi, Giovanni, Nelson, Richard R. and Winter, Sidney G., editors, *The Nature and Dynamics of Organizational Capabilities*, Oxford University Press, Oxford and New York, pp. 99-123.

Glaser, Barney G. and Strauss, Anselm L., 1967, *The Discovery of Grounded Theory: Strategies for Qualitative Research*, Aldine, Chicago.

Griffin, A. and J. R. Hauser, 1996, Integrating R&D and marketing: a review and analysis of the literature, *Journal of Product Innovation Management*, 13, 191-215.

Gupta, A. K., S. P. Raj and D. Wilemon, 1986, A model for studying the R&D-marketing interface in the product innovation process, *Journal of Marketing*, 50, 3, 7-17.

Håkanson, Lars, 2007, Creating knowledge: The power and logic of articulation, *Industrial and Corporate Change*, 16, 51-88.

Henderson, Kathryn, 1995, The political career of a prototype: Visual representation in design engineering, *Social Problems*, 42, 2, 274-99.

Henderson, Kathryn, 1998, The role of material objects in the design process: A comparison of two design cultures and how they contend with automation, *Science, Technology and Human Values*, 23, 2, 139-74.

Hutchins, Edwin, 1995, *Cognition in the Wild*, Cambridge University Press, Cambridge.

Hellström, Tomas, 2004, Innovation as social action, *Organization*, 11, 631-49.

Kellogg, Katherine C., Orlikowski, Wanda, J., and Yates, JoAnn, 2006, Life in the trading zone: Structuring coordination across boundaries in postbureaucratic organizations, *Organization Science*, 17, 1, 22-44.

Kjellberg, Hans and Helgesson, C-F, 2006, Multiple versions of markets: Multiplicity and performativity in market practice, *Industrial Marketing Management*, 35, 7, 839-55.

Nightingale, Paul, 1998, A cognitive model of innovation, *Research Policy*, 27, 689-709.

Nightingale, Paul, 2003, If Nelson and Winter are only half right about tacit knowledge, which half? A Searlean critique of 'codification', *Industrial and Corporate Change*, 12, 149-183.

Schumpeter, Joseph, A., 1943, *Capitalism, Socialism and Democracy*, George Allen and Unwin Limited, London.

Siggelkow, Nicolaj, 2007, Persuasion with case studies, *Academy of Management Journal* 50, 1, 20-24.

Star, Susan Leigh and Griesemer, James R., 1989, Institutional ecology, 'translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39, *Social Studies of Science*, 19, 387-420.

Suchman, Lucy A., 1987, *Plans and Situated Actions: The Problem of Human-Machine Communication*, Cambridge University Press, Cambridge and New York.

Suchman, Lucy A., 2005, Affiliative objects, *Organization*, 12, 3, 379-99.

Turley, Darach and Gieger, Susi, 2007, Exploring Salesperson Learning in the Client Relationship Nexus, *European Journal of Marketing*, 40, 5/6, pp662-681

Tushman, Michael L., 1977, Special boundary roles in the innovation process, *Administrative Science Quarterly*, 22, 587-605.

Weick, Karl E., 2007, The generative properties of richness, *Academy of Management Journal*, 50, 1, 14-19.

Yin, R.K., 1994, *Case Study Research: Design and Methods (2nd Edition).* Sage, Newbury Park.

Table 1: Six Cases within the Case

	Chemistry characteristics	***Selling characteristics***
Case 1	Simple diluting of scaling treatment on a new installation	Selling to non-CMS customer & 'I challenge your chemistry'
Case 2	Bio-infection on an established installation	Getting customer to act, green chemistry
Case 3	Corrosion & carrying water within a pipeline	Technical collaboration with customer
Case 4	Un-programmed problem solving, demulsification at a mature oil field	Close network, selling to new entrant
Case 5	Testing & validating established products for new use	Technology personnel undertaking marketing at trade show
Case 6	Developing new chemicals delivery medium	Radical innovation, disruption, excellent field trial performance, disrupting sales & production

Table 2: Three Versions of Subchem's Activities

	Version 1, routine business	***Version 2, incremental innovation***	***Version 3, radical innovation***
Technology	Tests & repeat prescriptions	Diagnosing problems, tests, product recommendations, field trials, independent trials	New products from novel 'green chemistry' bases;
Sales	Sales personnel embedded at customers' premises, acting within CMS	Change-outs, substitution warnings, 'I challenge your chemistry'	Green chemistry to field trials; new delivery medium sold via another company
Customers	Cost focus	Demonstrate value to us, undertake change-outs as promised in tender	Some companies willing participants in trials, given first-use discount

[1] Companies compete by developing products, including in mature industrial settings. Schumpeter (1943) is synonymous with 'creative destruction', which Flaherty (2000) develops as 'intelligent adaptation'. Creative destruction refers to a focal company's established products, and activity networks involved in developing, producing and selling these, extending to customers as end users, as much as it does to its competitors' products. Competition by product development recasts considerations of price and costs. Sure, companies compete on margins for established products, but price wars, empirically, are rare. Rather, managerial concerns with costs extend from the activity networks of established products to include those under development. The costs of development activities are within the ambit of managerial accounting, even if the expected revenues are highly uncertain in magnitude and timing. And pricing new products is made more complex by the imperative to recover development costs, and perhaps support development activities generally, as well as being a highly visible dimension of the creative destruction style of competition and selling.

[2] The main focus of environmental regulation is the OSPAR agreement, which covers the North Sea (the Convention for the Protection of the Marine Environment of the North-East Atlantic, or OSPAR Convention, was opened at the Ministerial Meeting of the Oslo and Paris Commissions in 1992). Subchem's UK activities extend to the Norwegian sector of the North Sea as oil companies are tending to merge UK and Norwegian activities into North Sea business units. Norwegian environmental regulations tend to lead those in the UK, and are being merged through the OSPAR process.