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“Stretch” – the impact of new processes and products on established process plants

Jonathan Ayles

Manchester Institute of Innovation Research, Manchester Business School, University of Manchester, Manchester M13 9PL, England

Abstract for ‘Managing R&D, Technology and Innovation in the Process Industries’, 5-6 May 2011

In 1966 a wide hot strip mill was commissioned in Ghent, Belgium for an initial capacity of 1.75 million tonnes of steel strip per year. During the years 2007 to 2009 the same rolling mill produced 6.5 million tonnes of steel per annum – almost four times its rated capacity.

The Sidmar wide strip mill is an example of ‘stretch’ - the ability of process plant to produce output far beyond its initial design capacity due to subsequent improvements in operating practice, process control, and progress in ‘bolt-on’ equipment and feedstock. ‘Stretch’ is the potential for further expansion, development and upgrading in the process industries. It is the way in which established plants respond to subsequent improvement in process and product technology.

One aspect of stretch, the notion of “learning”, has been widely studied. Learning is the ability to cut costs or raise output with cumulative operating experience. But the concept of pure learning does not capture the heterogeneous mix of control equipment, capital spending, upstream innovation, “bolt on goodies”, feedstock changes and alterations in product specification that explain the steady expansion in processing capacity of existing plants.

This paper develops a taxonomy of ‘stretch’, unpicking these various sources of performance improvements. Stretch is related to key innovations in the process industries. Some of these are generic such as direct digital control systems. Some innovations are highly specific to a particular installation or process. The taxonomy of stretch covers inter-locking changes in hardware, software, experience, intensity of use (including scheduling and maintenance), improvements in preparation of raw material feedstock and improvements in specification of finished products.

Potential stretch can be anticipated at the design development stage, before capital investment begins. Initial designs can provide for potential future expansion. Yet, other sources of stretch are unforeseen by initial designers, builders and operators. Detailed examples are drawn from rolling mill design for strip and plate in the steel industry and guided weapons development in the defence sector.

Balanced innovation portfolio funding and its impact on new product performance

Manuel Bauer¹, Jens Leker²

¹Manuel.Bauer@uni-muenster.de

²Leker@uni-muenster.de

All at the Institute of Business Administration at the Department of Chemistry and Pharmacy, University of Muenster, Leonardo-Campus 1, DE-48149 Muenster, Germany

Based on the theory of complementarity (Ennen, Richter, 2010 and references therein) and drawing on the strategic portfolio management literature (Roussel, 1991, Cooper, 1999, Chao, 2008) we develop hypothesis about how balancing innovation activities in a trade-off situation impacts innovation performance.

Innovation portfolio managers constantly have to decide which kind of innovation projects to pursue. Since innovation projects require financial funding for their execution and R&D budgets are a scarce resource in the management of innovations, managers need decision guidelines which should serve two purposes: First, they need to disaggregate the complexity of the innovation portfolio management task into mutually exclusive but collectively exhaustive dimensions. Second, they have to provide normative guidance for allocating scarce resources along these dimensions. Results from our research contribute to establishing such guidelines for the management of innovation portfolios in large chemical companies.

Based on extant literature from the strategic innovation portfolio management stream (Roussel, 1991, Cooper, 1999, Day, 2007, Chao, 2008) and the organizational learning literature (Grant, 1996; Nonaka, Toyama, Nagata, 2000), we disaggregated the decision making process of resource allocation in an innovation portfolio along four dimensions in two distinct knowledge domains: innovativeness and innovation type in the knowledge *application* domain and locus and kind of knowledge creation in the knowledge *creation* domain. Our core hypothesis is that pursuing innovation activities that belong to these dimensions, in particular process vs product R&D, radical vs incremental innovation projects, basic vs applied R&D and external vs internal R&D, in a balanced and simultaneous manner will result in increased innovation performance compared to pursuing only one activity in each dimension. Based on our analyses of objective data from 70 strategic business units (SBUs) from 15 companies in the European chemicals industry, we found general support for our theory.

In particular, we find strong support for our hypothesis in the context of the knowledge application domain. With respect to the innovativeness dimension, our findings provide empirical support for studies that suggested the positive joint impact of pursuing innovation projects of different innovative degrees on innovation performance (Kleinschmidt, 1991, Day, 2007, Chao, 2008). Therefore, we deliver further evidence for the theory of innovation portfolio management that advocates the joint but balanced execution of radical and incremental innovation projects in order to optimize the risk-return trade-off with respect to innovation performance.

With respect to the innovation type dimension, very few studies today empirically investigated the complementary nature of product and process innovations with respect to innovation performance, i.e. the impact that the joint execution of product and process innovation activities has on new product sales (Kraft, 1990, Reichstein, Salter, 2006). We provide further evidence for the suggested complementarity between process and product innovation activities.

At the same time, we extend the repertoire of methodologies to investigate complementarity by using relative objective explanatory variables which are easier accessible than absolute objective data. We used OLS regression analysis to estimate the curvilinear (inverted u-shape)

relationship between new products sales as dependent variable and a latent quadratic explanatory variable, representing the share of R&D budget allocated to one mutually exclusive innovation activity (instead of the other) in each of the proposed dimensions. By comparing the increase in explanatory power when estimating the quadratic form of the model instead of the linear one we obtained significant evidence (via F-tests) for our hypotheses.

In light of the chemical industry, we find that more than 7% (5 out of 70) of the SBUs in our sample do not pursue any radical innovation project. This may be due to an inherent, culturally induced risk aversion. Applying tools suggested by academics like Day's "real, win, worth it"-screening method may help to overcome such overstated organizational risk aversion in innovation portfolio management.

Our finding of the complementarity between product and process innovation also has considerable implications for the praxis of innovation portfolio management in the chemical industry. 16% of all SBUs in our sample did not invest in process innovation activities (while all companies invested in product innovation). However, we show that when executing product and process innovations simultaneously, the impact of "share of process R&D" on new product performance is significantly positive. Keeping in mind the strong arguments from case examples (Pisano & Wheelright, 1995) and practitioners (Linn 1984) for the combinative execution of product and process innovation activities, we suggest, that innovation portfolio managers make process innovation activities a fix element of their innovation portfolio.

With respect to the knowledge creation domain, our hypothesis of a curvilinear relationship between resource allocation along the respective innovation activity dimensions and new product success was not supported by our analyses. Instead, we found a linear relationship between investing in basic R&D and new product performance. Based on this observation, we provide arguments for the assumption that the chemical companies we investigated systematically underfund basic R&D activities which results in lower new product performance.

With respect to the second dimension within the knowledge creation domain, i.e. the locus of knowledge creation, we could not provide any significant evidence for either a linear or a curvilinear relationship with innovation performance.

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Towards a Process Definition: Key Dimensions and a Conceptualization for Improving Process Development

Johan Frishammar^{1,*}, Ulrich Lichtenthaler², Anders Richtner³

¹ *Luleå university of technology, Luleå, Sweden*

² *University of Mannheim, Mannheim, Germany*

³ *Stockholm School of Economics, Stockholm,, Sweden*

* *Corresponding author. Tel: +46 902 491407, , E-mail: Johan.Frishammar@ltu.se*

Keywords: Process development, process definition, case study

Abstract

Prior research into new product development shows that the early creation of a robust, well-defined product definition is critical to overall new product development success (Cooper et al., 2004; Seidel, 2007). In short, a product definition represents the goals of the development project. As such, it allows for a clearer understanding of several important issues, including physical properties, development time, costs, technical expertise, market potential, risk, and organizational fit (Kim and Wilemon, 2002).

The development of new processes is also driven by goals, but these tend to be different from those in product development. In essence, process development is conducted to improve a firm's production processes. Thus, process development is often conducted to achieve internal efficiency, such as cost reductions, increases in production volumes, improved quality and reliability, or lower emissions (Lager, 2002). Process development thus implies deliberate organizational attempts to change or modify the production process (Baer and Frese, 2003). Moreover, process development typically spans multiple functions in a firm, which makes it systemic (Frishammar et al., 2011; Gopalakrishnan et al., 1997). Therefore, a "process definition" – the process equivalent of a product definition - appears critical to guide process development. So far, however, no conceptualization of a "process definition" exists in the extant literature. This article bridges this research gap. The purpose of our article is to propose a conceptualization of a "process definition". In addition to specifying its key dimensions, we describe the process by which it is created and highlight the managerial implications resulting from it.

Empirically, we draw on data from a longitudinal, multiple case study of four process firms in the metal- and minerals industry. Our primary data consists of 32 deep interviews with key respondents from R&D, process development, manufacturing, and other functions concerned with process development. In addition, internal documents on process development were studied as well.

Our results show that a "process definition" is created through an iterative trial-and-error process, including experiments in bench scale, lab scale, and full scale production. Furthermore, we show that standard conceptualizations of product concepts are not applicable to the process domain. Accordingly, prior insights that can be gained from earlier research into new product development tend to be somewhat limited. Rather, specific contingencies such as the anticipation of production needs, anticipation of end product changes, the need for investment in new process technology, and internal risk assessment constitute key dimensions of a "process definition". These findings are particularly relevant to process development managers, plant managers, and development engineers

interested in increasing the efficiency of production processes. In light of potential interdependencies between process development and product development, the findings also have implications for R&D- and product innovation managers.

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The impact of demand led innovation in process industries: A case study on the role of customer interaction on performance in the paper industry.

Colin J. Hazley*

BIT Research Centre, Aalto University, Espoo, Finland

**Corresponding author: tel: +358 404873930, email: colin.hazley@aalto.fi*

The main contribution of knowledge in this paper is the implications of demand led innovation on R&D activities and innovation performance in a typical process industry. The key research question investigated is does higher levels of customer understanding translate into better performance in terms of innovation. To help assess this research question a performance framework is established to measure and compare performance across different areas of business within a large multinational paper manufacturer.

First of all, market orientation theory is utilised to measure just how externally orientated each area of business is. In line with market orientation theory both objective and subjective measures of performance are established. The former measures are typical financial performance measures which can be compared against competitors while the latter measures relate more to measures of innovation and customer interaction.

Secondly, the innovation theory utilised attempts to measure different types of innovation within each area of business. One set measures broad categories of innovation, which include those to measure typical innovation in process industries (product and process innovation) as well as those elements closer to customer and service type innovations (market and organisational innovation). Another set utilises success factors thought to be more relevant to process industries.

Thirdly, knowledge management theory is combined with more recent literature in the area of customer interaction (as a means to acquire customer insight and understanding but which extends well beyond Von Hippel's earlier work) to help assess levels of tacit understanding across the different areas of business.

Utilising the combined assessment framework it is shown that market orientation is positively associated with objective performance (financial) and subjective performance (innovation) and that higher levels of customer understanding (customer interaction) are also positively related to better performance. Given that a U-shaped relationship was found between tacit understanding and performance, there are profound implications for business strategy and R&D management.

Keywords: *Market orientation, Innovation, Performance, Customer Interaction/Understanding*

UNCOVERING MANAGERIAL ISSUES IN THE FACE OF ENERGY EFFICIENCY INNOVATION

Céline JULLIEN, Sylvie BLANCO

Professors, CITE (Center for Innovation, Technology and Entrepreneurship)

Grenoble Ecole de Management

R&D Management Conference, 2011

Abstract

The energy revolution is on route. Climate change and sustainability issues are now more than before influencing the trajectory of technical change in the energy sector. Both the private and the public actors are investing in the development of energy efficiency solutions, trying to envision the future of energy consumption and encompass its overall potential negative impacts. These developments are taking many directions among which new sources of production - like renewable energy; “smart grid” systems in electricity and smart metering solutions for final consumers. The rhythm of these technical changes is today speedier than before, given the development of information and communication technologies (ICTs) that have opened up the design of more complex and systemic solutions, and the creation of potential new services. The acceleration is also due to the numerous applications of these solutions, like in buildings, factories, transport, etc. Therefore, the energy industry that used to be characterized as a stable and mature process industry is now experiencing the transition toward a phase of potential disruptions and industrial reconfiguration.

A thorough understanding of the ongoing revolution through the lenses of innovation dynamics theories allows us to specify the managerial challenges incumbents are facing. Namely, transitioning from a specific to a fluid phase of the innovation life cycle requires to be able to break the rules in its own industry, mastering new entrants venue and coping with many strategic issues that may arise at the same time: deregulation of production and distribution mechanisms; renewed production processes due to technological change; new marketing practices as for distribution channels and pricing strategies; major changes in consumer values and behaviors; increased societal and environmental awareness to cope with; growing role of public institutions.

This calls for aligning innovation capabilities of firms with innovation challenges at stake through appropriate and dynamic management practices. This paper develops such a research models with a thorough search for emerging management practices that sound potentially relevant to the innovation challenges. Our aim is to contribute to disruptive innovation by incumbents in their own industry taking into account industrial specificities with notably, the problem of experimenting process infrastructures and innovation dynamics. Another objective is to set the ground for more discussion and collaborations between academic and practitioners in the field of innovation management as a way to accelerate the production and dissemination of advanced knowledge and its impact on managerial practices.

Illusion of Scope

Difficulty of Management of Technology in the Chemical Industry

Kazumi Nishino^{1,*}, Hiroyuki Itami²

¹Tokyo University of Science, Tokyo, Japan

²Tokyo University of Science, Tokyo, Japan

* Corresponding author. Tel: +81 352287823, Fax: +81 352287692, E-mail: knishino @rs.kagu.tus.ac.jp

Management of technology in the chemical industry, particularly in those firms in the upper stream of chemical tree of products, is very different and sometimes more difficult compared with the MOT in other industries. One of the major reasons for its difficulty we want to stress in this paper is what we call 'illusion of scope'. In terms of the scope of products that a chemical company can offer profitably, they tend to have an illusion which will not materialize and thus will fail in many of their attempts in diversification of their product and business lines, like a downstream integration into more value-added products or a horizontal movement into new chemical products using their technology accumulation. It is an attempt to capitalize on apparent 'economy of scope' which will end up as a dream never comes true, thus illusion of scope.

We take the case of a major petrochemical company in Japan who tried to commercialize a new basic chemical material (new polyolefin co-polymer) found in their lab, which has such an attractive list of physical properties, like transparency and refractive index, and find several instances of illusion of scope at work.

There are three reasons for the illusion of scope, all originating from the very nature of the chemical technology and the structure of the industry. First, too wide application potential for many newly found chemical compounds, which implies the difficulty of targeting the final market and especially the difficulty of perseverance in the commercialization in the targeted market. This is the illusion of scope in horizontal diversification. The second is the illusion of vertical diversification. When some chemical firms attempt downstream integration from mere production of chemical materials to more value-added products, they tend to underestimate these technical and investment hurdles and thus to end up selling so-so products at a price that cannot cover the investment cost. The third is the illusion of scope of real customer needs. The firms in the upper stream do not usually have the information on real customer needs and need to set up a 'messenger boat' between the chemical firm and the customers, which can convey such information. This is a case of business system design of interface with the customer, too.

One of the essences of the MOT in a chemical firm is the fight against the illusion of scope and we propose 'closed' open innovation as one of the countermeasures against illusion of scope. The chemical firms should closely exchange information with the customers and the fabricators and cooperate with them. This is a proposal about business system design of interface with them.

Keywords (3 to 7): *Illusion of scope, Closed open innovation, Chemical industry, Management of technology, Business system*

Allocating and managing R&D in the steel and material industry to prepare for ULCOS technologies and low carbon pathways¹

Lead Author : Dr. Rynikiewicz, Christophe

Abstract

The need for innovation towards sustainability and for a low carbon future has gained momentum in the last few years following different studies on emission reduction scenarios such as the Factor 4 scenario for France or the Stern review.

Various interdisciplinary initiatives are investigating the drivers of transitions in socio-technical systems towards low carbon pathways. The aim of the IDDRI-EpE (2004-2008) study on “industrial scenarios facing global change” was to look at the implication for the materials industry. Indeed, the study hypothesis state that the use of materials (and energy) will be profoundly altered in the 30-50 years to come as major changes in the infrastructures and products that support our many energy dependent services (mobility, shelter, heat, light, etc.) are expected. These changes will be significantly amplified by greenhouse gas emission constraints.

In this paper, we will, firstly, introduce the framework mobilised to study the evolution of the environment of selection of new eco-technologies in the material industry and the questions raised by the industrial partners in the IDDRI-EpE study, such as the evolution of demand (qualitative and quantitative evolutions), drivers for the evolution of market shares of technologies and understanding of how economies may evolve towards a much less carbon-intensive development profile.

Secondly, we examine the network formation, aims and deliverables of the ULCOS (Ultra Low CO₂ Steel Steelmaking) radical technologies and the research agenda of the EU Steel Technology Platform (ESTEP). In addition to the selection of emerging low carbon technologies for steel production, the steel industry also engaged in the SOVAMAT project to investigate possible evolution of the services associated to materials and the move to Product service systems.

Finally, we report from selected interviews with steel R&D managers and discuss the challenges in the implementation of the research agendas in the steel industry. Different trajectories of socio-technical systems transition are intrinsically linked to the behavioural and cognitive norms of individuals, businesses, communities, sectors, and governance institutions (Geels & Schot, 2007). The transition to low carbon innovation and possible new business models inevitably requires a ‘knowledge transition’ among such actor groups to enable better understanding and potential adoption of emerging technical, pricing and policy options.

Keywords : innovation, technology selection, ULCOS, industrial culture

¹ This paper draws on the research within the ULCOS project and also EpE-IDDRI “scenarios industriels sous contrainte carbone” during 2002 - 2008

CHALLENGING A DOMINANT INDUSTRY LOGIC: TECHNOLOGICAL DISCONTINUITIES AND DISRUPTIVE BUSINESS MODELS IN THE DRUG INDUSTRY

Sabatier V.^{1,2,*}, **Kennard A.**³, **Mangematin V.**¹

*: Corresponding author, tel.: +33 476.706.528

1 : Grenoble Ecole de Management, F-38000 Grenoble, France

2 : GAEL UMR INRA/UPMF, 1215, F-38000 Grenoble, France

3: Genostar, F-38330 Montbonnot, France

valerie.sabatier@grenoble-em.com,

adrienne.kennard@genostar.com

vincent.mangematin@grenoble-em.com

Keywords: dominant logic, business model, industry life cycle, drug industry, technological discontinuities.

ABSTRACT

Based on an analysis of recent changes in the drug industry, this paper seeks to identify which are the triggers of change in an industry's dominant logic, defined as the general scheme of value creation and capture shared by its actors. Breakthrough innovations leading to technological discontinuities are a necessary, but not sufficient, condition for the disruption of such dominant logics. The emergence of new business models questions an industry's existing value chain and the relations between its actors. This article suggests that, in mature industries experiencing strong discontinuities and when technological uncertainty is high, business models will tend to fit into the dominant logic of the industry and value chains will remain unchanged. But, as the new technologies evolve and uncertainty decreases, *disruptive* business models will emerge and challenge dominant industry logics and reshape established value chains, especially if they involve new and diversifying players joining the industry.

Characterising the difficulties in the Upgrade Cycle in a commodity process industry: Evidence from a single case study in the UK packaging industry

Christopher Simms and Paul Trott

Attempting to move away from commodity based products and related activities into higher value added ones remains one of the key challenges for R&D Managers. This research paper focuses on developing an understanding of these challenges in the UK packaging industry. The research focuses on a case of a single firm, within this process industry, that largely produces commodity products. The paper particularly focuses on Lager's (2000) product degradation-upgrade cycle model, and characterises the 'upgrade' aspect of this model. The paper presents the findings of a three-year research project with one of the largest packaging manufacturers in Europe. The findings provide insight into the problems faced by the company in their R&D activities attempting to 'upgrade' from producing largely commodity products to differentiated functional products. Finally, we provide insights into the management of R&D with regards to the company's position in the supply chain, and particularly highlight issues experienced with regards to acquiring knowledge and working with 'downstream' customers and other supply chain members.

Patent strategies in the process-related industries

Martin P. Schmidt
 French, German and European Patent, Trademark & Design Attorney
 IXAS Conseil, 15 rue Emile Zola, F-69002 Lyon

Process-related industries are industries that manufacture products using one or several heavy processes called here "key processes" for making large quantities of products. Many key processes (such as petrol refining, Haber-Bosch synthesis, aluminium electrolysis, grinding of minerals, shredding of end-of life vehicles, sawing silicon ingots) are known as such for a long time but have been continuously improved over the years and decades.

Patent claims can be directed to a product or a process. Both types of claims can be relevant to process industries. While the distinction between product claims and process claims is legally relevant, it is not a good starting point for strategic analysis. We will focus-here on what we call "process-related claims", i.e. claims that either cover a process (such as an improvement of the key process or a preparatory step) or a product (such as machine or part thereof, or an auxiliary product) that is essential for carrying out the improved key process.

The fundamental difference between the product obtained by the key-process and the subject-matter of the corresponding process-related claim is the following :

- If the product obtained by the key process is novel, it will become state of the art as soon as it has been sold (or otherwise disclosed to the public) for the first time; it can also be a known product that is already known and thus unpatentable.
- The subject-matter of a process-related claim (such as the key process itself or a process or machine necessary for making it work) is not visible to the public because it is used the factory. As a consequence, it can, at least in principle, be kept secret over a long period of time.

This opens both legal problems and strategic options that do not exist for the product that results from the key process.

Legal problems are related to the proof of patent infringement: According to a longstanding misconception, process claims are difficult to enforce because it is difficult to gain evidence. Due to peculiarities of national civil proceedings, this has never been true in certain countries such as the U.S.A, U.K. and France, but has actually been true in others such as Germany. However, European Directive 2004/48/EC on the enforcement of Intellectual Property Rights has set new standards for EU member states to adapt their rules of civil proceedings in order to facilitate the proof of infringement. As a consequence, within the European Union, the situation has greatly improved.

Strategic options for process-related inventions, some of which are available for products obtained by such process, include the following:

- (i) file a patent application immediately,
- (ii) do not patent at all but keep secret as long as possible,
- (iii) keep secret and patent at a later stage when the competitors are likely to catch up, or when a joint-venture, a spin-off or any other event either make it unlikely that the secret can be kept any longer or require patenting.

The proper choice of patent strategy depends on the overall strategy, on the type of industry, on the competitive situation, on the product obtained from the key process, on the technical aspects of the process-related invention, on the way how the know-how can be kept secret. Several examples will be discussed, and a few guidelines will be formulated based on experience.

An operations management perspective on innovation in process companies: the production system revisited

Per Storm¹, Thomas Lager^{2,*}, Peter Samuelsson³

¹ Raw Materials Group, Solna, Sweden

² Grenoble Ecole de Management, Grenoble, France

³ Outokumpu Stainless AB, Stockholm, Sweden

* Corresponding author. Tel: +33476706060, Fax: +33476706455, E-mail: Thomas.lager@grenoble-em.com

A subset of manufacturing industries has been selected and clustered together under the heading of Process Industries according to the concept of family resemblance. It is initially recognised that these industries have many attributes in common and that they differ significantly in many respects from other manufacturing industry, but that they also differ in some respects from each other. Using a simplified model of the production system as input – transformation – output, a newly developed theoretical framework has been deployed in the analysis of company innovation activities. The framework consists of four sets of characterising indicators, including e.g. percentage of captive raw material supplies, material conversion characteristics, product differentiation and conversion intensity. Industry representatives from three companies from Mineral Industry, Steel Industry and Food Industry were selected and the framework was then used as a template in further discussions and in the development of three illustrative “mini-cases”.

The respondents were first asked to comment and supplement pros and cons in general for different positions on each indicator in the first explanatory part of the template supplied. They were then asked to position their company production system on each indicator in the framework. For the company’s position on each indicator, they were afterwards asked to rate the importance of each indicator to the company and how strongly this indicator related to the importance of raw material innovation, process innovation and product innovation. The results indicate that the conceptual framework can be used as a tool in the analysis of company innovation in the Process Industries.

It is thus argued that in the analysis of innovation activities in process companies, the product/market perspective ought to be supplemented by a production/operations management perspective, to enable the development of innovation strategies that are more related to company operations and possibly also better adapted to existing and future company production facilities. Combining the information from both perspectives and striking a proper strategic balance could then hopefully be helpful in the search for a better fit between “market and machine” for companies in the Process Industries. The exploratory empirical findings give initial theoretical insight, but can already be utilised as an instrument in discussion and for a review of company innovation activities and development programmes.

Keywords: Innovation, operations management, process industry, production system, raw materials, process innovation, product innovation

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