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Letter from the Editor

What's ahead in 2011?

Although the chemical industry has recovered strongly from the crisis, a potential double-dip recession still frightens even the greatest optimists. Further exacerbated by unstable economic conditions, emerging markets, and shifting political power relations, decision makers in the chemical industry seek to prepare their companies for 2011. Apart from aligning existing resources and capabilities with established markets and customers, the long-term success of chemical companies is dependent on the openness to new, promising business opportunities, such as bio- and nanotechnology, sustainability-oriented innovation, or health care applications. Accordingly, chemical companies not only have to derive their goals from widely diverging forecasts, but also to resolve the core trade-off between flexible strategies and efficient operations. In order to present promising avenues for dealing with this challenge, this issue of the Journal of Business Chemistry comprises the following articles:

In his commentary "Industrial biotechnology becomes a key competitive factor", Manfred Kircher highlights the potential role of biotechnology in the future. To lever the inherent business opportunities, he recommends a cluster approach that is marked by partnering along the whole biotechnological value chain. Thereby, he draws upon the German Graduate Cluster Industrial Biotechnology [CLIB] to substantiate his commentary by means of a best practice example.

With regard to the question of how companies should behave in turbulent environments, Mattia Bianchi, Alberto Di Minin, and Federico Frattini, then, introduce a new amphibious organization type. Based on a paradigmatic case study of an Italian chemical company, their article "Towards a phenotype of the amphibious company: an illustrative case from the chemical industry" comprises the development and discussion of specific behavioral traits that are associated with amphibious companies, i.e. doing different jobs good, diversifying in multiple market arenas, brokering and bridging across business networks and absorbing knowledge from the outside. According to the authors, firms that successfully implement these practices are likely to be the "fittest economic species in today's hypercompetitive business arenas".

In the second research article "Exploring market knowledge in product development of chemical firms", Armand Smits, Geert Vissers, and Ben Dankbaar identify important market knowledge dimensions that underlie the innovation process of chemical firms. They emphasize segment knowledge, application knowledge, product usage knowledge, and customer knowledge as the building blocks of successful innovation and introduce an overarching knowledge framework for market-oriented product development. Their findings are grounded on a qualitative research approach that comprises a multiple case study of six product innovation projects in six chemical companies.

In our practitioner´s section, Ralf Schmidt presents success factors for effective pricing in times of crises. To determine the specific impact of the financial and economic crisis 2008 / 2009 on the chemical industry, he and his team conducted interviews with 80 pricing managers. These experts emphasize, for example, the importance of the structuring of pricing processes or a result-oriented alignment of the pricing in general to survive a crisis unscathed.

Now, please enjoy reading the first issue of the eighth volume of the Journal of Business Chemistry. We would like to thank all authors and reviewers who have contributed to this new issue. If you have any comments or suggestions, please do not hesitate to send us an email at contact@businesschemistry.org.

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Commentary

Industrial biotechnology becomes a key competitive factor

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Industrial biotechnology is established since decades in producing diverse products such as enzymes, amino acids, enantiomerically pure pharma-actives and more (Haas et al., 2010). However, in spite of these successful examples biotechnology still plays a minor role in the chemical industry, accounting for only 3-6% of the global sales volume. It is more or less only successful in those niches where petro-chemistry does not work: enzymes and enantiomerically pure products are simply not available by chemical synthesis. This limitation is going to be cleared away through modern biotechnology. Beside the products already mentioned before, non-natural chemicals will be also available. They will be the future precursors in procedures combining biotechnology and chemical synthesis.

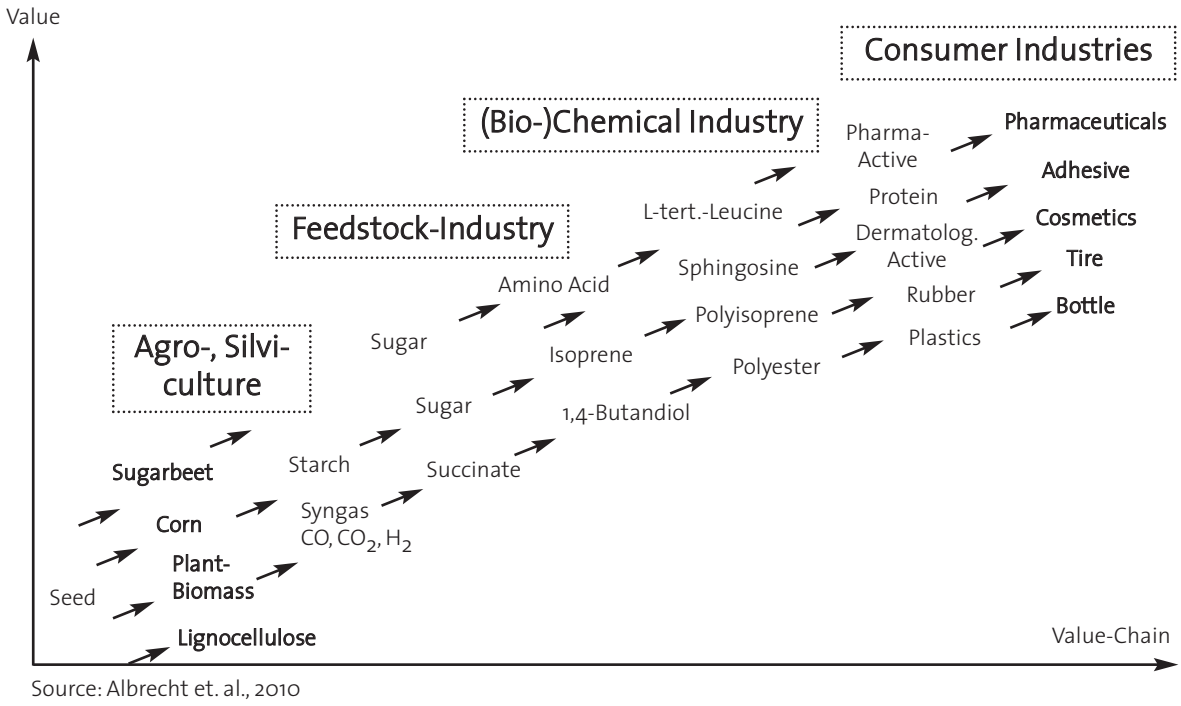
Bio-/chemical processes will be the crucial building block of the future production system sweeping the entire industry. It is the vision of an industry predominantly based on raw materials, which recycles auxiliary and end products. A core element of this vision, as unanimously supported by the European Union as *Knowledge-Based Bio-Economy* (KBBE) and by the German government as *BioÖkonomie*, is industrial biotechnology (Research DG, 2005; King & Hagan, 2010). Accelerating this development needs more joint and strong efforts of industry and academia in pushing the recently emerging synthetic biotechnology, improving continuous processes, reducing downstream processing costs and integrating biotechnological and synthetic process steps. While reaching commercial success through early R&D is not guaranteed, public support is necessary and already given. However, public funding should take even more consideration of industrial relevance, including projects that are close to the commercialization stage, such as pilot plants.

At this point the future feedstock market needs to be discussed. When the chemical industry enters the agricultural market it will compete with producers of food, feed, fibers, rubber, and increasingly bio-energy. Therefore the chemical industry is eager to explore alternatives to agricultural feedstock like lignocellulosic agricultural waste and wood. Providing commercial solutions in this field is another common and urgent challenge to academic and industrial process development.

Incorporating the perspective of the European chemical industry regarding the competitive availability of renewable feedstock is of particular relevance. With Europe's limited agricultural area its industry will largely depend on imports from countries and regions, such as the US, Brazil, South-East Asia and Russia (King & Hagan, 2010). When the future trend of producing bulk precursors from renewable carbon sources for chemical applications is gaining momentum, such production units may be most competitive in those regions. Therefore, European chemical sites, with no renewable carbon resources nearby, are forced to focus continuously on the competitiveness of their processes and a sustained pipeline of value-adding products. In some way industrial biotechnology is an innovation driver itself: the more successfully it achieves industrial transformation of renewable feedstock, the more it becomes a critical competitive factor.

Establishing industrial biotechnology is an extremely complex issue. Numerous hurdles need to be overcome. Questions of science (synthetic biology), technology (integration of biotech- and synthetic process steps), feedstock availability (infrastructure), politics (legislative framework), training (academic and technical staff) and public acceptance need to be answered. However, the biggest challenge may

Figure 1 The value chain of industrial biotechnology



Source: Albrecht et. al., 2010

arise from the development of a new, agricultural and silvicultural value chain reaching from feedstock- and biochemical transformation to consumer industries (Figure 1, Kircher, 2006).

It is obvious that walking this way alone is too challenging even for big companies. To be successful, industries need access to scientific, technical and business competencies in all steps of the value chain. Therefore, in Germany the cluster CLIB^{2021}, (Cluster industrielle Biotechnologie 2021 e.V.), supported by the German Federal Ministry of Education and Research (BMBF) and the Ministry of Innovation, Science and Research of the German state of NRW (MIWF), has been founded.

Today this type of cluster-forming is widely perceived to be most promising in paving the way to the KBBE. Recently, the European Commission acknowledged 3 European clusters as role models: the Bio-Hub in France, the BE-Basic in the Netherlands and the CLIB^{2021} in Germany (Research DG, 2005). Through partnering along the biotechnological value chain, such organized clusters are crucial in winning the global competition in industrial biotechnology. All academic, industrial and financing stakeholders should join. The time is right now!

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Journal of Business Chemistry

Research Paper

Towards a phenotype of the amphibious company: an illustrative case from the chemical industry

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The paper explores the phenotype of the amphibious company, which is intended as the fittest economic species in today's hypercompetitive business arenas and hence the most likely to survive and prosper. Four behavioral traits are proposed and discussed as distinctive of amphibious companies: doing different jobs good, diversifying in multiple market arenas, brokering and bridging across business networks and absorbing knowledge from the outside. The paper illustrates these arguments through a paradigmatic case study of an Italian firm operating in the chemical industry, which has been able to survive a challenging crisis by adopting an amphibious behavior.

Introduction

Classical strategic management theories, such as the five competitive forces (Porter, 1980) or the strategic conflict (Shapiro, 1989) approaches, advocated that a firm's competitive advantage is achieved and protected by seeking the most favorable industry positioning and by erecting strong entry barriers. In an environment characterized by largely predictable changes in markets and technologies, well defined industry boundaries, and fairly limited international competition, firms tried to maximize value creation by combining internal investments in R&D and in downstream assets, such as manufacturing and distribution (Chandler, 1990). This resulted in what has been called "closed" approach to industrial innovation management, which is based on the assumption that successful innovation requires control. Accordingly, companies invested heavily in internal R&D and hired the best people to invent, research, develop, manufacture and commercialize in-house new products and services. For the largest part of the 20th century, this closed model worked well, as evidenced by the history of success of corporate R&D centers such as IBM's and AT&T's Bell Labs (Chesbrough, 2003).

However, at the end of the 1990s a number of dramatic environmental changes have started to challenge these traditional views in strategic management and industrial innovation. Knowledge and technologies are increasingly fragmented and internationally dispersed. Information grows in importance as a determinant of economic value creation (Shapiro and Varian, 1999). Change in markets and technologies occurs at a rate faster than ever and, most importantly, is largely unpredictable (Chesbrough, 2003). Technology fusion and industry convergence continuously redefine blurring knowledge and industry boundaries (Kodama, 1992). The number and complexity of technologies incorporated in new products and services are soaring, whereas industry lifecycles increasingly shorten (Bayus, 1998). Many more markets have taken on the cha-

racteristics of networks and economic actors are increasingly interconnected (Chakravorti, 2003).

Under these circumstances, established strategic management paradigms become clearly inadequate, due to their static underlying assumptions on positioning and entry barriers. As a result, new strategic frameworks have been proposed. One of the most influential is the resource-based view (RBV) of the firm, which argues that competitive advantage stems from scarce difficult-to-imitate, firm-specific resources owned or controlled by firms (Wernerfelt, 1984). Accordingly, the firm is seen as a portfolio of idiosyncratic and difficult to trade assets and competencies (Teece, 2007), which are becoming predominantly knowledge- and technology-based (Grant, 1996; Granstrand, 1998). However, some scholars have recognized that resources alone are not sufficient to explain a firm's competitive advantage (Ray et al., 2004). A company may have indeed technologies which can eventually ensure superior value creation performance, but may lack the capability to undertake the efforts necessary to realize this potential. This argument is brought forward by the dynamic capabilities (DC) framework, introduced by Teece and colleagues (Teece et al., 1997), which argues that competitive advantage not necessarily stems from firm-specific assets, but from how they are configured by managers (Cavusgil et al., 2007). Dynamic capabilities are a set of specific and identifiable strategic and organizational processes through which firms within dynamic markets manipulate resources into value-creating strategies (Eisenhardt and Martin, 2000).

Dynamic capabilities have been associated with a set of firm-level characteristics and recurrent behaviors like flexibility, velocity, collaboration attitude, ability to create and exploit connections (Helfat et al., 2007). Companies like Google, Procter & Gamble or IBM have been cited as exemplary of these attitudinal traits (Huston and Sakkab, 2006; Harreld et al., 2007). Much research has been done to investigate the antecedents of firm-level dynamic capabilities (Rothaermel and Hess, 2007) and, in this regard, a set of organizational routines have been identified as managerial and controllable antecedents of superior capabilities (Bianchi et al., 2009). However, what is lacking is a complete understanding of the phenotype[1] of those firms that are the fittest to survive the current environmental context. Put it differently, what is the internally consistent set of observable characteristics of the most successful companies? Organizational routines and capabilities have been conceptualized as the genotype[2] of a company (Nelson and Winter, 1982) and have attracted much attention from strategic management and organization scholars. We need however to search for the external manifestation of this genotype, so as to improve our ability to identify those companies that are the most likely to survive the current competitive environment and those that, instead, will suffer from competition and therefore deserve managerial attention and intervention. This would significantly increase the predictive power of our knowledge regarding the roots of sustained competitive advantage.

Our main argument in the remainder of the paper is that firms possessing dynamic capabilities that make them apt at successfully competing in the current economic and competitive environment show a phenotype which is similar to that of amphibious species in the animal world. Indeed we claim that certain observable characteristics of amphibians (e.g., frogs, toads, salamanders) resemble those of companies outperforming their competitors in high-technology, high-velocity and turbulent industries. We illustrate our arguments through a paradigmatic case study of an Italian firm operating in the chemical industry, which has been able to outperform competitors and to survive a challenging crisis by adopting an amphibious behavior.

The phenotype of the amphibious company

Which are the typical observable traits of the amphibious company, that underlie its superior chances of survival and success in the current hypercompetitive and highly interconnected business environment? The purpose of this section is to introduce the distinguishing elements of the phenotype of the amphibious company, using comparisons taken from the natural world and making explicit reference to established management and organizational theories. Amphibians have been iden-

1) Phenotype is defined as "the physical appearance of an organism as distinguished from its genetic makeup. The phenotype of an organism depends on which genes are dominant and on the interaction between genes and environment", Collins English Dictionary, 2003.
2) Genotype is defined as "the genetic makeup of an organism as distinguished from its physical characteristics", Collins English Dictionary, 2003.

tified as the "perfect pioneers" in the animal world, as they have managed to spread the most, and best, across the Earth (Van Bocxlaer et al., 2010). Their evolution started from South America, but they were able to rapidly diffuse through Asia, Europe and Africa. In Australia, amphibians have been imported by man and they have spread like wildfire. They attained a sub-cosmopolitan distribution in a very short time frame and the 500 known species show an interesting diversity in larval and adult adaptation on each continent. Like toads and frogs, amphibious companies are the pioneers of the business world. The next paragraphs illustrate the four behavioral traits that characterize amphibious companies, i.e. doing different jobs good, diversifying in multiple market arenas, brokering and bridging across business networks, absorbing knowledge from the outside. Of course these four logically distinct courses of action are strictly intertwined and reinforce each other, therefore it is very likely that they are observed contemporarily.

Doing different jobs good

A first distinctive trait of the successful company in today's business environment relates to its ability to effectively administer internal operations, i.e. those processes that occur within the corporate walls, as well as external relations, i.e. those governance forms that involve interaction and collaboration with external stakeholders (suppliers, clients, competitors, universities, etc.). The benefits of establishing external linkages include access to complementary assets and competencies (Teece, 1986), increased flexibility, sharing of risk and costs, learning opportunities and creation of shared standards (Schilling, 2005). The most successful companies have shown an incredible capacity to combine and balance internal and external operations both in the exploratory and exploitative phases of the innovation process (March, 1991). Effective exploration of new value creating opportunities is achieved by integrating in-house R&D efforts with technological collaborations, in the form of acquisitions of new technology based firms, in-licensing, corporate venturing, R&D consortia and joint R&D with universities and research centers (Bianchi et al., 2010; Van de Vrande et al., 2006). Similarly, superior exploitation has been increasingly secured by using a carefully balanced mix of internal application of new technologies, through new product development, and external commercialization of proprietary knowledge, in the form of out-licensing, spin-offs and joint-ventures (Lichtenthaler, 2005), as well as outsourcing of low value added activities and contract manufacturing. The following quote by Jeff Weedman, vicepresident of P&G's external business development, is exemplary of how the wise combination of inward and outward operations is at the basis of a firm's search for competitive advantage: *"There are many kinds of competitive advantage. The original view was: I have got it, and you don't. Then there is the view that I have got it, you have got it but I have it cheaper. Then there is I have got it, you have got it, but I got it first. Then there is I have got it, you have got it from me, so I make money when I sell it, and I make money when you sell it"* (Chesbrough, 2006, p. 201). However, the practice of balancing internal and external operations is extremely complex: these are often dissimilar and somehow antithetic business activities, which typically require highly heterogeneous organizational cultures and values. Amphibious companies are those that have overcome inertia to change, have surpassed strong cultural barriers, also known as Not-Invented-Here (NIH) and Not-Sold-Here (NSH) syndromes (Chesbrough, 2003), and have opened their organizational boundaries to the external environment.

This ability to be good at very dissimilar activities, e.g., hunting, moving and escaping predators in water as well as outside it, is a typical trait of amphibious species. Amphibian is derived from the Ancient Greek term "αμφίβιος" (amphibious), which means both kinds of life, "amphi" meaning "both" and "bio" meaning "life". The term was initially used for all kinds of combined natures. Eventually it was used to refer to animals that live both in the water and on land.

Diversifying in multiple market arenas

Instead of playing defensively and erecting barriers to protect market position, the fittest companies rapidly diversify their activities in different market arenas, in search for superior rents and growth opportunities (Wernerfelt and Montgomery, 1988). Diversification along various dimensions, i.e. product and geographies, is a characteristic of successful firms and a fundamental determinant of corporate growth (Granstrand, 1998). Entry into new product markets gives rise to economies of scope and scale, enables information advantages and resource sharing,

reduces risks and earnings volatility in times of declining traditional markets (Kim, Hwang & Burgers, 1993). These benefits are especially evident when business diversification is technology related, i.e. it builds upon or extends existing technological competencies. The growing recognition of the general purpose nature of many technologies, i.e. of their "potential for pervasive use in wide range of sectors" (Bresnahan and Trajtenberg, 1995), has pushed firms to multiply the exploitation of their corporate jewels by adapting them to a broad number of application fields. This has been the case of P&G, which started in 1837 as a candle maker, and over 180 years has diversified into soaps, emulsifiers, surfactants, household, health and beauty care products, razors, batteries and chips, through a dynamic process of leveraging existing competencies and creating new ones (Sakkab, 2002). Supposedly Google is following P&G's footsteps, as from Web search engines it is moving to operating systems, cell phones, wind energy and cars that drive themselves (New York Times, 2010). Such a diversified strategy is consistent with the theory of core competencies by Hamel and Prahalad (1990), which argues that a limited set of core competencies, if wisely integrated in multiple combinations, can allow access to a wide spectrum of markets and result into a product's advantage that is perceivable to the customer and cannot be easily imitated by the competition.

An important feature in the evolution of amphibians is diversification (Van Bocxlaer et al., 2010). Toads and frogs have radically diversified their characteristics and behaviors to adapt to very dissimilar environments: toads that weigh more than 2 kilograms and are more than 20 centimeters long can be found in the Tropics as well as in semi-desertic areas, while those that are only 1 centimeter long and weigh less than a few grams live up on the African mountains. Some species are viviparous and give birth to 6-8 toads each time, others spawn more than 18,000 eggs every time. Overall, we are aware of the existence of more than 500 species of frogs and toads, but many more will be discovered in the near future.

Brokering and bridging across business networks

A third distinctive trait of the most successful companies is their ability to broker, i.e. to connect otherwise disconnected actors and knowledge pockets. Brokers create bridges which cross structural holes (Burt, 1992). These connections represent invaluable business opportunities whereby the "tertius iungens" actor is in the best position to spot new discoveries and to control information flows (Obstfeld, 2005). In a globalized world characterized by highly distributed knowledge and competencies, it is not "know how" which matters in determining a firm's competitive advantage. Rather, it is "know where" and "know who" that discriminate between successful and unsuccessful innovators. Amphibious companies have realized that going too deep into all the relevant scientific domains or technical fields is not worth the required investment: staying at the frontier is extremely costly and the payback time is not compatible with today's shrinking technology life cycles. Instead they rapidly move on the surface of business networks and knowledge landscapes, aware that breakthrough innovations increasingly stem from the cross-fertilization of traditionally unrelated scientific disciplines (Kodama, 1995). This practice has been named technology brokering by Hargadon and Sutton (1997) and refers to the intelligent recombination of existing knowledge from different sectors. Using the words of the science-fiction author William Gibson, technology brokering draws on the belief that "the future is already here. It's just not evenly distributed" (The Economist, 2003). Geox, an Italian footwear manufacturer, has grown to be one of the world leading players thanks to its breathable waterproof sole shoes. This breakthrough innovation was achieved by using a special membrane from NASA's astronaut spacesuits. Immersion, a small California-based company, showed a similar ability to fill technology gaps by successfully transferring the proprietary TouchSense technology, developed mainly for medical applications, to the automotive industry, thanks to a properly managed collaboration with BMW.

The ability to rapidly move on the surface can be observed in frogs and toads. Amphibians are not as effective as fishes when it comes to swim in the depth of a pond. However, they are much faster and more agile when they move close to the surface of the water and when they jump on the land to hunt insects or escape a predator. This startling agility derives from their long and slender legs and from the suction pads on the ends of the toes.

Absorbing knowledge from the outside

The fittest firms show a superior attitude when it comes to absorbing knowledge from the environment and make a profitable use of it. The concept of absorptive capacity has been developed to identify a firm's ability to recognize the value of external knowledge, assimilate and utilize such knowledge to commercial ends (Cohen and Levinthal, 1990). In today's hypercompetitive business arenas, this capability has become of paramount importance for ensuring sustained competitive advantage. Put it with the words of Astra Zeneca's CEO, "ninety-nine percent of everything exciting that happens will happen outside your own research lab" (Escribano et al., 2009). Amphibious companies have porous boundaries that allow the effective osmosis of knowledge from outside in. In addition, they are equipped with organizational mechanisms, e.g., dedicated functions or gatekeepers, that ensure a proper identification, evaluation and reception of that knowledge (Kale et al., 2002). Genzyme has achieved its success by absorbing early stage ideas and projects from universities or small biotech companies and developing them into novel therapies for previously untreatable diseases (Chesbrough, 2006). Thanks to this business model, Genzyme is one of the only three companies, the others being Amgen and Genentech, that make profits in these hard times of the biotech industry (Pisano, 2006).

Amphibians (especially frogs) are known for the unique feature of breathing largely through their highly permeable skin. Oxygen is dissolved in an aqueous film on the skin and passes from there to the blood. Tiny blood vessels and capillaries, under the outer skin layers, make this possible. The ability of frogs to absorb a critical resource like air through several dispersed elements of their body resembles the capacity of amphibian firms to assimilate knowledge and technologies from the many inter-organizational relationships they establish with external organizations, such as clients, suppliers, competitors, universities and individuals.

Phenotype and genotype

Our main argument in this paper is that these four behavioral traits, which can be observed in the fittest and most successful companies competing in today's hypercompetitive businesses, are the external manifestation of a set of dynamic capabilities which have been extensively investigated by strategic management and organization research in the last years. A well-known taxonomy of a firm's dynamic capabilities is that proposed by Teece (2007), who identifies "sensing opportunities", "seizing opportunities" and "reconfiguring assets and management systems" capabilities as those underlying sustained competitive advantage. These should be conceived as three classes of routines - the "genes" of the organization (Nelson and Winter, 1982) which enable a firm to express a certain behavior and course of action, precursor of superior competitive advantage, when interacting with the external environment. The same genes seem to characterize amphibious species. For instance, they are extraordinary at sensing future events. Scientists have discovered that toads are able to detect earthquakes up to five days in advance, because they are able to detect pre-seismic cues such as the release of gases and charged particles (weak signals), and use these as a form of earthquake early warning system (Grant and Halliday, 2010). Furthermore, the reconfiguring ability is clear in amphibians' metamorphose from a juvenile water-breathing form (tadpole) to an adult air-breathing form.

In this section of the paper we have described the externally observable behavior of the fittest firms in today's business environment, in the belief that this will increase the predictive and practical impact of research into the most recent conceptualization of the RBV. In the remainder of this article, we will discuss the case of a chemical company which is illustrative of the phenotype of the amphibious firm.

Methodology

FROG Inc. (the real name of the company has been blinded for confidentiality reasons) is an Italian firm operating in the electrochemical industry, which employs 700 people and has an annual turnover of €250 million (data as of 2008). Its core business is in the supply of components for the production of chlorine, caustic soda and other industrial electrochemical applications. FROG is an exemplary case to investigate in the scope of our research because it has managed to recover from a difficult crisis at the end of the 1990s thanks to a radical shift toward an amphibious behavior. Indeed, the four behavioral traits identified in the previous section can be clearly observed together with their impact on the

impressive record of sales and profits that FROG has scored in the most recent years.

Our empirical analysis is based therefore on a single case study methodology, which allows to study a complex phenomenon under particularly insightful circumstances, capturing its intangible and hidden facets (Eisenhardt and Graebner, 2007). This paper makes an illustrative use of the case study, i.e. it leverages qualitative evidence to illustrate with practical examples the concepts that are developed in the conceptual argument (Siggelkow, 2007). To this purpose, the investigated firm has to be "*very special in the sense of allowing one to gain certain insights that other organizations would not be able to provide*" (Siggelkow, 2007, p. 20). The major strategic shift implemented by FROG in order to surge back to profitability is exemplary in this regard. The single case study methodology has obvious limitations, in terms of generalization and external validity, as noted by Yin (2003). However, the reader should notice that we do not attempt to draw generalizations from the single case study under analysis, but we use this paradigmatic case as a helpful illustration of the phenotype of an amphibious company.

Information about FROG, Inc. was collected through semi-structured interviews with key informants and internal documentation. Specifically, we went after the following steps during the analysis:

- First, we met the Chief Executive Officer of FROG to inform him about our research project. During this meeting, we asked the CEO to introduce ourselves to several respondents who could help us in data collection. We decided to interview: (i) the head of the R&D function; (ii) the head of the Business Development function; (iii) the Chief Execution Officer of one of the joint ventures established by FROG; (iv) a university professor who advised FROG on its strategic plan. Interviewing multiple respondents is beneficial to reduce the risk of retrospective and personal interpretation biases, that might undermine the validity of case study research (Yin, 2003);
- Then we personally interviewed the selected informants; we undertook one semi-structured interview for each respondent (each interview lasted on average two hours). Direct interviews followed a semi-structured guide, that comprised a set of open questions regarding the evolution of FROG's strategic management approach over time;
- Secondary information was collected in the form of reports, charts and transcripts of meetings between managers. This provided the researchers with background information about FROG and the strategic decision making to which it was accustomed. Above all, these information sources were integrated, in a triangulation process, with data drawn from the direct interviews, in order to avoid post hoc rationalisation and ensure construct validity (Yin, 2003). No relevant inconsistencies between information collected through interviews and secondary sources were identified;
- All interviews were tape-recorded and transcribed. After transcription, a telephone follow-up with each respondent was conducted with the aim to collect missing information.

Data collected through the case study were manipulated before being analysed. In particular we applied the following methods (Miles and Huberman, 1984): (i) data categorisation, which requires the decomposition and aggregation of data in order to highlight some characteristics (e.g., type of relationships that the firm establishes with external actors during innovation activities) and to facilitate subsequent analyses; (ii) data contextualisation, which entails the analysis of contextual variables that may cause unpredictable relationships between facts and circumstances. Then, the manipulated data were aggregated to obtain a systematic description of the evolution of FROG's strategic behavior over time. Finally, explanation-building procedures were used so that the causal relationships between events and circumstances could be identified. These structured procedures for data collection and analysis helped enhance the reliability of the research (Yin, 2003).

The case study

Founded in the 1920s and still led by an Italian family, FROG is an established, leading player in the global chemical industry. In particular, FROG, Inc. is a major supplier of process technologies and equipment for the production of chlorine, caustic soda and derivatives, as well as of noble metal-coated electrodes for chlor-alkali applications. Its main customers are large chemical producers. The business arena is characterized by industry concentration and slow technical change, with traditional technologies still playing a critical role.

Within this context, FROG has distinguished itself as a successful innovator, with 60 professionals and more than €10 million annual investments devoted to Research & Development activities. A long record of breakthrough technologies, in the form of anodes and electrodes for electrochemical processes, has enabled FROG to control more than 50% of its reference markets and experience high profit margins. This until the end of 1990s.

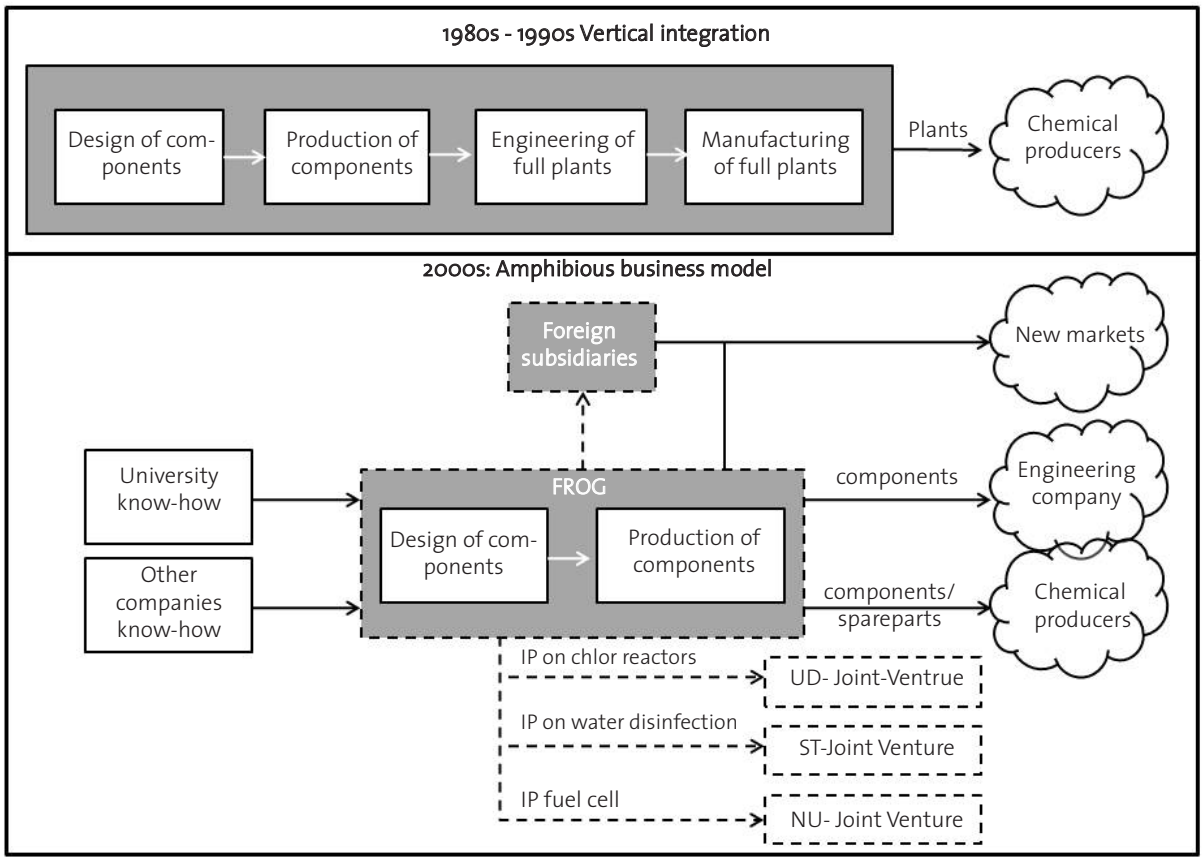
The traditional business model of FROG can be defined as vertically integrated. Economic value is created through investments in the development of strong technological know-how and in the design of superior electrochemical components. The components are manufactured and incorporated into the production of chemical reactors, which are then sold to chemical producers. All these activities are performed in-house under the strict hierarchical control of FROG's management. At the turn of 20th century, however, changes in the competitive scenario, including raising levels of competition, shrinking market demand and reduced margins, especially in the business of chemical reactors' manufacturing, had very negative impacts on FROG's economic and financial results. FROG's profits plummeted by more than 40% in the first years of the 2000s and the firm had to lay off 10% of its workforce. The competitiveness of FROG was indeed severely challenged by this downturn.

FROG jumping out of the crisis: the amphibious strategic shift

The initial strategic response to the crisis turned out to be unsatisfactory. A number of isolated initiatives, such as the relocation of some products to the low-end of the market or the closure of a few factories, were soon discarded. Things changed after an internal reorganization and radical turnaround, with the design and implementation of a major shift in FROG's strategy.

The key initiative regards the incisive re-invention of the firm's business model, devised after a careful look and understanding of its

Figure 1 Re-invention of business model by FROG, Inc.



changed environment. In fact, FROG divests its downstream, and now less profitable, activities related to the production of reactors, while focusing on the upstream development and supply of high-tech components. Managers realize that core components are now the "bottleneck" assets in the value chain, the critical elements enabling differentiation and value creation, while resources and competencies related to machinery and equipment for chemical plants are "commoditized" and can be more easily "cashed out" through external paths to market. The re-invention of the business model is depicted in Figure 1. This strategic shift gives rise to a number of amphibious initiatives that are described in the following.

The first relates to technology exploitation. The new strategy can be described with the words of the Head of the Business Development function: *"an exclusively internal appropriation of value for core technologies on components; an outward exploitation approach with external partners for non-core technologies on plants and reactors"*. Accordingly, while intellectual property (IP) on components and related production processes continues to be vertically controlled and internally exploited, about 100 patents related to machinery and chemical plants are transferred to three newly formed joint ventures (JV), labeled in this paper NU-JV, UD-JV, ST-JV (see Table 1 for additional information). These technologies worth €10 million are used to capitalize the new companies and FROG gets in return equity stakes in the JVs from 50 to 20 per cent. Joint venturing is chosen as an external governance form because the resulting fully-dedicated firms allow to achieve an effective integration between FROG's superior technology and the downstream complementary assets held by leading partners in some segments of the chemical market. FROG has paid particular attention to the selection of the most suitable allies. In the case of UD-JV, an established leader is selected to provide best-in-class distribution channels, brand and market presence. In NU-JV, FROG partners with a small and highly entrepreneurial firm possessing fuel cell technologies that are perfect complements to FROG's IP. The ally in ST-JV is instead chosen because of the existence of a close alignment of strategic objectives and similarity of culture.

The impressive economic results achieved by these joint ventures and their leading position in their own market niches provide evidence for the development by FROG of a superior ability in managing external relations in addition to internal operations. In 2008, the total revenues earned by the JVs and accruing to FROG proportionally to the equity owned, amount to €60 million, twice the figure in the 1990s when the related technologies were exploited in-house. Revenues from the JVs currently constitute 22 per cent of FROG's total turnover. The effective combination of inward

Table 1 Main features of the Joint Ventures established by FROG, Inc.

JV Name	Birth Year	FROG % Equity	Objectives	FROG contribution	Partner contribution	JV business
NU-JV	2001	20	Risk and cost sharing	Technological	Technological	Fuel cells
UD-JV	2000	50	Achieve large scale	Technological + Marketing	Technological + Marketing	Engineering company
ST-JV	2002	30	Access to complementary assets	Technological	Marketing and brand	Seawater treatment

and outward modes is an amphibious trait that distinguishes FROG from its closest competitors: *"FROG's approach is unique: competitors in the industry play alone, they barely have any collaboration"* (CEO of UD-JV).

Beginning from the 2000s, FROG has diversified in different arenas adapting its core competencies to market specificities, just as amphibians do. Diversification has occurred along both product and geographical dimensions. All the initiatives of product diversification can be defined as technology push, i.e. they build upon FROG's strong and distinctive electrochemical know-how. In few years, FROG has entered into several related markets: electrogalvanizing, surface finishing, industrial water treatment, electronic printed circuit boards, coating services, energy saving technologies. Not only these strategic moves exploit the general purpose nature of electrochemical technology, but they also leverage the rich humus of FROG's design and development engineers, process specialists, project managers, and quality engineers, to solve a wide range of customer needs. Some of these diversification opportunities are pursued through internal growth and direct investments into wholly owned divisions, as in the case of a new business unit for energy saving technologies, others are seized instead through external vehicles. This is the case, e.g., of FROG's entry into the copper electrowinning business. FROG's managers realize that their R&D department has developed a superior solution for the treatment of copper pickling. However, electrowinning has never been considered as an attractive or conquerable market for the vertically integrated FROG, due to its small size.

Consistently with the new amphibious business model, FROG's business development function proactively identifies and establishes a strategic alliance with an Australian minerals group, which possesses the most adequate machinery to incorporate FROG's anode. Although it is too early to say a definitive word, the success of this initiative is demonstrated by the uninterrupted sales growth since 2004. FROG has also diversified into new geographical markets. In addition to its traditional subsidiaries in Germany, Brazil and USA, FROG has opened branches in China and India, with the aim to meet the demand of rapidly developing local industries and provide superior service to regional clients. The Indian branch is actually a joint venture with a local partner. This and the copper electrowinning examples show that the amphibious traits that we have presented as distinct in our conceptual development are strongly intertwined in practice. They act in concert and make up the phenotype of an amphibious company, which ultimately allows to achieve and sustain competitive advantage. This reinforcing mechanism will also emerge in the remaining of the case study.

FROG's new strategic approach is not limited to technology push, i.e. driven by the need to maximize the exploitation of its technological assets. In the recent years FROG has also distinguished itself for spotting business opportunities in totally unrelated fields and making unobvious connections between users' unsatisfied needs, information holes and other firms' shortages. Playing the role of the broker and activating a network pull mechanism, FROG has developed product innovations by wisely mashing up ideas and knowledge dispersed in the environment. This has occurred, e.g., in the development of electrodes for swimming pools' disinfection. It all begins at an international fair, where people from the business development function at FROG are informed about the almost unseized potential of the residential swimming pool market and the large room for improving existing disinfection technologies. A business unit at FROG has a prior knowledge of the leading supplier of swimming pool controls in the U.S. market, which agrees to sign a commercial partnership. By doing so, FROG earns access to the ally's portfolios of customers, including construction companies and pool builders. From a technical point of view, FROG starts adapting its electrodes to the new application. To integrate a technology that is lacking in-house, FROG acquires the majority stake of a small supplier of electrodes. FROG's components have now reached 30% of the global swimming pools market and generate annual revenues in excess of €20 million. Although the profits in the swimming pools market are not so high, this cross-fertilization operation has generated additional cash for FROG and has helped diversify the risk of its business portfolio.

This last example also points to the importance of assimilating technological knowledge from the environment. FROG has formally dedicated 15% of its R&D budget to in-source ideas and solutions at different stages of development, which can be incorporated into its product development process. The preferred partners are universities. For instance, FROG

has absorbed from a university in Central Italy innovative know-how in microbiology and agronomy. This knowledge has allowed to adapt FROG's electrochemical technologies to the needs of agricultural businesses with the aim of improving cultivation processes. For this purpose, a spin-off venture has been created, where FROG holds an 80% equity share and university researchers the remaining 20%. The scouting of external innovations and their absorption has improved at FROG since the establishment of a dedicated business development function which acts as an effective antenna that scans and recognizes valuable knowledge pockets. The success with this business development function is due to the right mix of legal, marketing and technical competencies of its members and the decisional autonomy they have been assigned, coupled with a formal performance management system which makes them accountable for their choices.

Taken together, the introduction of external governance forms, the pursuit of business diversification, the brokerage across business networks and the absorption of knowledge from the environment have helped FROG to surge back to profitability. The company managers agree on the importance of these courses of actions, that we have classified as distinctive traits of the amphibious company: *"Reinventing our business model has made FROG a very leveraged and asset light company. Our revenue per employee figures are the highest in the industry"* (Head of R&D function); *"Our EBIT margin is more typical of Armani and other fashion companies than of chemical businesses"* (Head of the business development function). Our analysis shows that the transformation of FROG into an amphibious company is the result of the development of a set of firm-level dynamic capabilities. Superior reconfiguring capability by FROG is evident if we consider its ability to adapt resources and management systems to match the requirements of a changing environment. Superior sensing capability has allowed FROG to timely identify and calibrate opportunities for new businesses. From the analysis of internal reports, it emerges that the number of new business plans evaluated by the strategic committee has more than doubled with respect to the end of the 1990s. Finally, superior seizing, i.e. the ability to promptly address opportunities by committing investments and resources without delay, is evident in the rapidity with which FROG has established its joint ventures and has launched new products in previously unexplored markets.

Although it is outside the scope of the paper to study how these dynamic capabilities develop over time, the analysis of the case study indicates that the following factors favor their emergence in an organization: (i) a period of economic crisis which makes it evident to top management that a change in the firm's strategic approach is needed; (ii) a strong commitment from top management toward championing a company-wide process of analysis and search of new sources of sustained competitive advantage; (iii) the presence of effective social integration mechanisms that favor communication across hierarchical levels and the assimilation of shared corporate values and mission; (iv) the existence of an organizational culture that does not hinder out-of-the-box thinking, risk-taking and entrepreneurial individual behaviors.

Conclusions

The aim of this paper is to present and discuss the phenotype of the amphibious company, which is intended as the fittest economic species in today's hypercompetitive business arenas and hence the most likely to survive and prosper. It emerges from our analysis that the amphibious company is characterized by a set of distinctive behavioral traits, which become evident when it interacts with its external context, namely doing different jobs good, diversifying in multiple market arenas, brokering and bridging across business networks and absorbing knowledge from the outside. Whereas amphibious companies are the fittest in the current competitive landscape, firms that struggle to identify the most favorable industry positioning, protect it by erecting strong entry barriers, exclusively rely on internal knowledge and capabilities to develop new products and services are at a severe disadvantage. These firms had prospered instead in the past, in an environment characterized by largely predictable changes in markets and technologies, well defined industry boundaries, and fairly limited international competition.

The amphibian phenotype described in this paper captures and synthesizes into a single organizational species several behavioral traits that have been separately identified and associated to superior performance by some recent theories in the field of strategic management, e.g., open innovation (Chesbrough, 2003) and

ambidextrous organization (Tushman and O'Reilly, 1996). It is the observable manifestation of a set of organizational routines, which should be conceived as the genotype of the amphibious companies, i.e. "sensing opportunities", "seizing opportunities" and "reconfiguring assets and management systems" capabilities, which have received much attention in the recent strategic management and organization research (Teece, 2007). This body of research shows that changing established organizational routines is a costly and complex task (Nelson and Winter, 1982). Therefore, especially in those organizations with institutionalized practices and processes that are incompatible with the amphibious behavior, introducing the new phenotype can be very costly and time consuming.

The emergence and the positive impact on value creation and profitability of this phenotype are discussed in the paper by using an illustrative case study of a chemical firm which has overcome a dramatic economic crisis by adopting an amphibious behavior. The chemical industry (as well as the pharmaceutical and biotechnology) is perhaps one of those that have most been impacted by the radical environmental changes (e.g., international dispersion of knowledge and technologies, velocity and uncertainty in market evolutions, technology fusion and industry convergence) that underlie the success of the amphibious company. Here the superior ability of the amphibious firm to survive and prosper is therefore more easily observable. However, we believe that its distinctive behavioral traits are critical for competitive advantage and value creation in many other high-technology, high-velocity industries and business arenas, as the anecdotes reported in this paper suggest. Therefore, future research should investigate the generalizability of our conclusions, through carefully designed and conducted quantitative studies, which attempt to find a statistically relevant relationship between the observable amphibious behavioral traits and the presence of underlying sensing, seizing and reconfiguring capabilities. Furthermore, these future studies should explore the generalizability of our preliminary findings in other industries.

Most of the examples and cases discussed in this paper refer to medium- and large-sized companies. As it often happens, it is these firms that are the first to experiment new strategic behaviors and approaches in the search for superior competitiveness and economic value creation opportunities. However, there are no reasons to believe that small companies cannot benefit from becoming amphibious in the near future. Rather, the amphibious phenotype appears to be particularly adequate to enable small companies fill the resource gap with larger enterprises by leveraging their intrinsic flexibility and speed.

Despite its illustrative nature, our hope is that the paper can provide some valuable insights to managers in chemical firms about how to increase profits and fuel growth. This could be very important especially in the current economic downturn.

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Research Paper

Exploring market knowledge in product development of chemical firms

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Firms can enhance product innovation performance by continuously staying in touch with customers and the market in general. While studies on market oriented product development have identified several general dimensions of market knowledge used in product innovation, the nature of market knowledge that is specifically important in the chemical industry remains unclear. Because firm relevant knowledge resources are increasingly seen as being industry specific, filling this gap becomes more relevant. This study uses a multiple case study of six product innovation projects in six different companies to identify important market knowledge dimensions in the product development of chemical firms. Aggregated results from the six cases point to segment knowledge, application knowledge, product usage knowledge, and customer knowledge as being important market knowledge dimensions. Implications for theory and practice as well as avenues for further research are included.

This paper reports on research that aimed to identify the nature of market knowledge that is of importance for market oriented product innovation in the chemical industry.

As in many manufacturing industries, product innovation is important for chemical firms to keep their competitive advantage (Heinzelbecker, 2005). Consequently, it is no surprise that well respected firms in the industry have articulated product innovation strategies. The Dutch life science and material science company DSM, for instance, has appointed a Chief Innovation Officer and has set long term product innovation targets. Another example is Solvay. This Belgian chemical company has announced that 30% of the firm's income should come from new products or technologies developed within the past five years.

Product innovation can be described as initiating a new product idea and bringing it to the market. It consists of a collection of tasks that have to be performed by employees from multiple departments such as research, marketing and manufacturing (Sheremata, 2000). Within product innovation, processing market information is important. Already in the 1970s, Cooper (1979) concluded that including market information in new product decision-making was one of the controllable factors that contributed to new product success. Today it is widely accepted that companies have to stay in touch with their customers and the market in general as a precondition for successful product innovation (see e.g. Cooper, 2001; Kirca et al., 2005; Montoya-Weiss and Calantone, 1994). As Leonard (1995: 177) indicates, it seems that no information is more important to a firm "than information flowing in from the market, as this information shapes science into commercial product or service."

1 Views on market knowledge

Two streams of research that can be used as background for researching market

knowledge in product innovation are research on market oriented product innovation and studies on the Knowledge Based View of the firm.

1.1 Market oriented product innovation

In marketing science a firm's market focus and market information processing is captured by the concept of market orientation (Hunt and Lambe, 2000). Initially, two perspectives on market orientation emerged which, to some extent, can be considered as opposite viewpoints (Day, 1994; Homburg and Pflesser, 2000; Lafferty and Hult, 2001). The first perspective was developed by Kohli and Jaworski (1990) and is centred around behaviour while the second perspective, developed by Narver and Slater (1990), has a cultural viewpoint. Both the behavioural and cultural view of market orientation have weaknesses with respect to conceptualization and measurement (Oczkowski and Farrell, 1998), and there is debate on the value of each perspective (Jaworski and Kohli, 1996; Lafferty and Hult, 2001). Still, both perspectives are able to show that information on customer needs and wants is central to market orientation. Additionally, both balance an internal and external organizational view, both argue that the firm as a whole should respond to identified customer needs, and both maintain that the scope of market orientation goes beyond customers and incorporates competitors and the forces that shape customer needs such as governmental regulations.

How can a firm's market orientation enhance product innovation performance? The marketing literature answers this question by linking market information processing to strategy making and execution, particularly innovation. With few exceptions, it argues that a market oriented culture and the associated information processing behaviour reduces risk associated with developing new products and, therefore, enhances their success. Especially from the mid-90s onwards, many studies link market orientation to product innovation performance (Atuahene-Gima, 1995; Gatignon and Xuereb, 1997; Li and Calantone, 1998; Veldhuizen et al., 2006). Additionally, the mediating role of product innovation in the market orientation – performance relationship has been analyzed (Han et al., 1998; Langerak et al., 2004). A meta-analysis by Montoya-Weiss and Calantone (1994) found that the proficiency of employees to perform marketing activities during the product development process has a strong positive effect on new product advantage. In a similar vein, the literature review of Brown and Eisenhardt (1995) indicated that a significant number of studies highlight the importance of customer involvement for the effectiveness of product concepts and better product designs. Also, a meta-analysis by Kirca and colleagues (2005), which included 114 studies, confirmed that a market orientation has a positive effect on organizational performance via product innovation. Besides product development effectiveness a market orientation may also improve product development efficiency. For example, based on an analysis of data from 103 product development projects from the chemical industry, Cooper and Kleinschmidt (1994) found that including a customer viewpoint into the new product development process reduced product development cycle time significantly. Additionally, it has been shown that market orientation not only enhances incremental product innovation performance but also has a positive effect on radical innovation (Atuahene-Gima, 2005; Baker and Sinkula, 2007; Kyriakopoulos and Moorman, 2004).

1.2 Knowledge Based View of the firm

Knowledge can be defined as 'information in context' (Nonaka et al., 2000). Within the framework of the Knowledge Based View of the firm, knowledge is regarded as important resource in organizations. It is argued that, in contrast to physical resources, organizational knowledge and its generation, transfer, integration, and application are idiosyncratic to the firm and are therefore an important source of competitive advantage (Grant, 1996; Kogut and Zander, 1992). Also, knowledge may extend its value more broadly than physical resources because it can be simultaneously used for multiple ends (Itami, 1987). Conner and Prahalad (1996) even go so far as to state that knowledge resources are the most important resources of the firm. Sometimes a distinction is made between information and knowledge (e.g. Ackoff, 1999). While information is seen as descriptive in nature, related only to past and present events and situations, knowledge is specifically predictive in that it allows future insights to be gained from past and current circumstances (Kock et al., 1997). However, in practice a distinction between knowled-

ge and information is hard to make and therefore we will use the term 'knowledge' to point to both information and knowledge.

From a marketing perspective two knowledge flows are particularly important for product development: the generation of market knowledge from the market environment outside the firm and its integration with technological knowledge to develop product designs (Allen, 1971; Ancona and Caldwell, 1992; Atuahene-Gima and Murray, 2007; Grant, 1996; Li and Calantone, 1998). To put these knowledge flows in practice requires management to improve knowledge storage and access, and facilitate an environment conducive to knowledge use. In addition, it requires organizational members active in day-to-day product development activities to acknowledge their existence and usefulness.

2 Market knowledge and product innovation

Insights from studies on market oriented product innovation and the Knowledge Based View of the firm may be combined in order to arrive at an inventory of general market knowledge dimensions in product innovation. Adams and colleagues (1998: 409), for instance, identified two dimensions of market knowledge: 'product concept development information' and 'business data'. Product concept development information "included all mentions of customer needs, what the customers were like, and designing the product…to achieve the concept." The second dimension, business data, included "all mentions of emerging trends in the market place, of competitors, of estimates of market size, segments and feasibility, and of whether or not this was a good business for the organization." Veldhuizen et al (2006: 361) make a similar distinction between customer information, concerning the understanding of customer problems, and environmental information, concerning competitor and general industry information.

While these general categorizations are of great value for theory and practice, it appears that knowledge which is created and transferred within an organization is inextricably tied to its specific context (Foss, 1996). One of the most important backgrounds in which organizational knowledge is situated is its industry environment (von Krogh et al., 1994). An industry environment shapes managers' perceptions because it provides an analytical context by which managers cope with uncertainties. Industries imbue organizational knowledge with meaning (Kogut and Zander, 1996). 'Industry recipes' frame managers' choices as they make decisions under ambiguous and uncertain circumstances. Thus, knowledge resources seem highly industry specific. As Winter (1987: 175) claims: "lessons derived from experience in one industry may be very misleading guides to knowledge related strategic resources in another." King and Zeithaml (2003), for instance, identified dozens of knowledge dimensions in hospitals and textile firms and concluded that only *one* comparable knowledge dimension between the two contexts could be identified. Thus, while general dimensions of market knowledge in product innovation have been developed, we expect that relevant dimensions may differ across industries. This paper deals with market knowledge in product innovation in the specific case of the chemical industry, asking "*what market knowledge is used in the product development of firms in the chemical industry?*" We aim to present a comprehensive and empirically derived framework of market knowledge dimensions that is relevant for both researchers and practitioners.

3 Research setting and methodology

A multiple case study strategy was used to investigate market knowledge as used in product development of firms in the chemical industry. This strategy is appropriate for two reasons. First, this study concerns a complex phenomenon (market knowledge) in the dynamic setting of product innovation in established firms. Looking into such a topic benefits from the extensive interaction with research subjects that case studies allow for (Yin, 1994). By using this strategy overlapping constructs can be disentangled and contexts can be taken into account (Lee, 1999). Hence, case studies allow for exploring the detailed nature of knowledge dynamics in product innovation. Second, our understanding of market knowledge in product innovation is incomplete and a case study strategy can be used to extend existing theory to new domains (Eisenhardt and Graebner, 2007; Yin, 1994). While single cases can richly describe the existence of a phenomenon, multiple case studies typically provide a stronger base for theory building and extension (Glaser and Strauss, 1967).

The chemical industry is a capital inten-

sive process industry which creates and transforms chemical substances to provide the market with functionally advantageous non-assembled products. It is dominated by large multinationals, has its roots in Europe, and is over a hundred years old (Cesaroni et al., 2004; Mahdi et al., 2002; Van Gils, 2010). We restricted the chemical industry to the C20 NACE code.

Our unit of analysis was the product innovation project in a chemical firm. This small unit of analysis helped to focus data collection because it allows for studying well-defined organizational events (Yin, 1994). Case selection started by contacting chemical firms that were members of trade organizations and research consortiums in the Netherlands, and/or the European Industrial Research Management Association. An additional selection criterion was that companies had a significant presence in the Netherlands, Belgium, or Germany for reasons of accessibility. After negotiating access we were able to work with six chemical companies. Because prior research has shown that most marketing and product innovation activities take place at the level of the business unit (Adler et al., 1999; Piercy, 1985; Workman et al., 1998), the business unit instead of the corporate level was selected as organizational context. Our first firm contacts referred us to persons working in the business units. The sizes of these business units ranged from €270 to €4,400 million in annual sales revenue, with an average size of €1,100 million. As a second step in case selection we selected one product innovation project per business unit as main case (Table 1). The products that were the results of these projects had to be just before market introduction or had been introduced into the market less than two years ago. The rationale for this requirement was that long finished projects would reduce the changes of contacting suitable respondents and the ones that could be contacted might have problems remembering the details of the projects. Also, market introduction can be considered as an intermediate measure of project success (Seidel, 2007). Because prior literature suggests that market knowledge is essential for project success, studying successful projects increased the changes that extensive market knowledge could be identified.

Data were collected by interviewing actors

Table 1 Overview of cases

Project	Cycle time	Business unit turnover Business unit focus	Interviews
Heat "New grade of plastic in existing application."[1]	S[2]: 2003 I[3]: 2008	~ €700 million Materials	12
Green "New chemical ingredient in existing application."	S: 2003 I: 2007	~ €800 million Specialty chemicals	4
Diffuse "Existing grade of plastic in a new application."	S: 2003 I: 2006	~ €300 million Materials	4
Anti-resist "New grade of fibre in new application."	S: 2004 I: 2007	~ €400 million Materials	11
Foam "New type of foam in new application."	S: 2005 I: 2008	~ €4,400 million Materials	9
Additive "Existing polymer in new application."	S: 1999 I: 2004	~ €250 million Specialty chemicals	4

[1] Description based on the perspective of the business unit
[2] S = Project start
[3] I = Market introduction

involved in the product innovation project, and organizational members who were related to this group such as senior managers. The use of multiple respondents allows information to be checked, thus providing the opportunity to control for potential biases of individual respondents (Dougherty, 1990; Goldon, 1992; Huber and Power, 1985). The interviews contained both general and more specific questions. In most cases, a single question ("Could you please describe how the project developed over time?") was enough to trigger the main process story. After the initial story, we followed up with in-depth questions, focusing on specific dates, working practices, milestones, events, and outcomes. Since there was no list of people that had been or were involved in the projects under study, the selection of respondents was based on information provided by other respondents. We finished data collection when additional data resulted in limited additional understanding (Glaser and Strauss, 1967; Lee, 1999). Respondents ranged from senior managers to operational staff and the interviews lasted between 50 minutes and 2.5 hours. Notes were taken and all interviews were taped and transcribed verbatim. Most interviews were carried out on-site, but three interviews were by telephone because respondents were located more than 500 kilometres away. Data collection started in 2006. Interview data were supplemented with archival data such as new product proposals, product announcements, product catalogues, presentations, and business press articles to cross-check initial findings. Overall the combination of interviews and archival data collection enabled a rich understanding of market knowledge resources used in product innovation in the context of the chemical industry.

Data analyses started with examining data from single cases. The aim was to get familiar with each case as a stand alone entity. We divided information in meaningful fragments (Miles and Huberman, 1994). These fragments were labelled with a few words to indicate the meaning of the fragment. For coding and data handling we used the qualitative data analysis package NVivo. During coding we generated preliminary notes of insights that emerged per case. This description was fed back for review by several respondents. We focused on similarities and differences between cases. Significant discrepancies and agreements were noted and further investigated. To further sharpen our findings and test their validity the cases were also systematically compared with existing literature (Eisenhardt, 1989). Iterating back and forth between data and theory resulted in the identification of a robust set of market knowledge aspects, such as, for instance market segment size, growth rate, and stakeholder behaviour. We then aggregated these aspects into four market knowledge dimensions as used in product innovation processes in chemical firms.

4 Market knowledge dimensions in product innovation

Our findings suggest that new product teams in the chemical industry use significant amounts of market knowledge in successful product innovation. This market knowledge is multidimensional and consists of *segment knowledge, application knowledge, product usage knowledge and customer knowledge*[1]. To successfully initiate a new product idea, develop it into a physical product, and introduce it into the market, project members had to take all of these dimensions into account. All four dimensions were found in projects in the area of specialty chemicals, as well as in projects in the area of materials. We will now discuss each of these market knowledge dimensions in some detail.

4.1 Segment knowledge

In line with other scholars (Daft and Weick, 1984; Day and Nedungadi, 1994) we do not assume that market environments are unambiguous realities. Project members and higher level managers make sense of their surroundings by defining market segments. These segments are given meaning through selective search, perception and simplification. They were based on experience and data already available, interactions with other organizations, and influenced by functional and personal backgrounds.

During product innovation market *segment knowledge* was searched for. Search was specifically aimed at quantifying segment *size*, in terms of volume or value, and segment *growth rate*, and at *stakeholder behaviour* (other than customer behaviour) that may influence customer preferences such as competitor moves and activities of distributors and governments (Table 2). Quantifying market size was main-

1) In this research, the term 'customer' relates to business-to-business customers of chemical firms such as downstream manufacturers.

Table 2 Segment knowledge

Project	Segment	Focus area(s) / Examples		
		Size	Growth rate	Stakeholders (others than customers)
Heat	Automotive 'under the bonnet' applications			"[For project Heat] we learned that temperature requirements of 'under the bonnet' applications were going up due to governmental regulations." *Product manager*
Green	Application area for chemical ingredient		"For this project, we used estimates on developments in market volumes of the chemical ingredient." *Business manager*	"....our business plan for [project Green] included a competitor analysis based on patent data." *Business development manager*
Diffuse	Edge-lit signage	"I tried to look at the [market] volume of edge-lit material for signage which was significant." *Business developer*	"...this information pointed to ultra slim edge-lit displays being a trend." *Product manager*	
Anti-resist	Tires			"We learned that reducing rolling resistance due to mandatory standards by the EU was a main priority of a large group of tires manufacturers." *Business manager*
Foam	High performance foams	"At the start of the project we quantified the market and identified certain applications for this [foam] material." *Marketing manager*	"[Global marketing] looked at volumes and future market expectations of high performance foams." *Sales manager*	
Additive	Plastics	"Our team managed to get knowledgeable about the sales volumes of several plastics." *Senior research associate*		

ly done by desk research while segment growth rate and stakeholder behaviour was identified by using desk research, customer contacts, and visiting conferences.

The market segment knowledge dimension has some parallel in the marketing and product development literature. It reflects what Jaworski and Kohli (1996: 126) have called "a sensitivity to the underlying forces that shape a market or an industry." Also Veldhuizen et al. (2006) identify competitor and industry information as important aspects of environmental information that is used in product innovation. A similar type of market knowledge in innovation is called 'business data' by Adams and colleagues (1998).

Good examples of efforts to quantify segment size could be found in projects *Diffuse*, *Foam*, and *Additive*. In the mid-90s the business unit in which project *Diffuse* took place, developed and introduced a specific transparent plastic sheet. This sheet had colourless light diffusing particles that cause light to diffuse forward. It was specifically engineered

for edge-lit signage applications, such as panels for airports, shopping malls, restaurants, and bus stops. It accepts light through its edges and redirects it to the surface for bright uniform illumination. This product was specifically targeted toward the edge-lit signage segment. As the head of innovation noted: "*Lighting has always been a defined 'meta-segment' where we sell our products and we always have worked on lighting applications in the past. Edge-lit signage is the specific market segment that is of interest when talking about this product.*" In 2002, in response to customer feedback, a business developer made some incremental adaptations to the product which caused renewed internal and external attention for the sheet. Internally business developers mainly tried to quantify the market for edge lit signage by doing desk research. As the business developer put it: *"This renewed attention made us study market reports…I tried to look at the [market] volume of edge-lit material for signage, which was significant."* Desk research as market knowledge generation practice to quantify market segments was also used in projects *Foam* and *Additive*. The marketing manager of *Foam* indicated: *"At the start of the project we quantified the market and identified certain applications for this material….we studied market reports to get familiar with the market space and with applications. You can buy market reports on high performance foam and where that goes into. After that we had some idea of what the market really was."* In project *Diffuse* project members acted within a market segment that was already familiar to the organization. The market segment for edge-lit applications was developed and used in, for instance, strategy discussions before the start of the project *Diffuse*. In contrast to project *Diffuse*, the market segments in projects *Foam* and *Additive* were developed during the initiation of the projects. Project members in these latter projects experienced the limits of their market segment frame of reference which forced them to rethink their routines. They had to label a newly identified market segment and communicate it to the rest of the organization, and they had to get familiar with this new segment before investment decisions could be made. A large part of these projects consisted of just getting familiar with market segments that were totally new to the organization. As a sales manager involved in project *Foam* put it: *"At the start of the project the organization had never sold high performance foam before, so the market research on this market segment is new to the organization."*

Projects were partly chosen on the basis of expectations concerning market segment growth. As a result, next to estimates on market segment size, also market growth rates were studied. Good examples of mapping growth rates are *Green*, *Diffuse*, and *Foam*. Project *Green* was focused on changing the feedstock and process technology of a chemical ingredient which could potentially influence the properties of the epoxy resin for which it was used. As the business development manager of *Green* explained, next to estimates of the market size for the chemical ingredient, the business plan for *Green* also *"had estimations on developments in market volumes and prices for our product."* While project members generally tried to quantify market segment size, for identifying growth rates qualitative information was added. In project *Diffuse*, for instance, additional qualitative data were gathered which reinforced the development team's conviction that edge-lit signage was a growing segment. To map dynamics in market segment size, next to desk research, additional market knowledge generation practices were applied. Product development teams complemented desk research by using (potential) customer contacts, and conferences and trade fairs to interact with the market. An example of using customer contacts to estimate growth rate is project *Foam*. In this project, a new product was developed in order to fill a gap that resulted from an incumbent foam producer phasing out a specific foam material. To estimate dynamics in the high performance foam market segment, marketing managers involved in *Foam's* development team were in direct contact with potential customers. As a marketing manager indicated: *"From a commercial point of view, first question was analyzing the reactions of customers of the incumbent material to the situation. Were we chasing a market space that was getting smaller because customers were also phasing out this material, or was it that they lost business because they couldn't continue what they were doing?"* Market knowledge generation practices in project Diffuse illustrate the use of conferences and trade fairs to estimate growth rate. As was pointed out by a product manager involved in project *Diffuse*: *"From attending trade fairs we learned about developments in the market. This information pointed to ultra-slim edge lit displays being a trend."*

A final area where market segment knowl-

edge was generated was the market segment stakeholders area. Mapping the behaviour of agents such as competitors and regulators in relationship with a market segment often provided the impetus to initiate a product development project or an early indication of the feasibility of a project. Examples of mapping the behaviour of market segment stakeholders are *Heat*, *Green*, and *Anti-Resist*. Project *Heat* clearly originated from studying developments in governmental regulations. By becoming aware of emission standards set by European Union and analyzing their impact on automotive 'under the bonnet' applications, *Heat's* home organization realized that their existing grade of plastic would not meet future heat resistance requirements of these applications. The need for efficient combustion engines, driven by Euro 5 and Euro 6 emission standards regulations, would result in engine designs with higher operating temperatures. At these temperatures the existing grade of plastic would melt and therefore existing customers were in need of a new type of plastic. As the product manager involved in *Heat* explained: *customers were in need of a new type of plastic. As the product manager involved in Heat explained: "Heat was born from market studies. We learned that temperature requirements of 'under the bonnet' applications were going up due to governmental regulations and we tried to anticipate by developing a new product."* For studying the behaviour of stakeholders, project members used the same practices as were used for mapping segment growth rates: desk research, customer contacts and visiting trade fairs and conferences. In project *Green*, for instance, the innovators mapped competitor behaviour by studying their patent activities from public sources. As the business development manager involved in Green put it: *"Next to estimates on developments in market volumes for our product market, our business plan included a competitor analysis based on patent data from patent databases."* While the employees involved in *Green* solely relied on desk research to map stakeholder behaviour, the product developers involved in *Heat* complemented desk research with conferences and industry meetings: *"I visited conferences and industry meetings where the automotive world presents future ideas and legislation influences on an ongoing basis….these visits, combined with studying trend reports were important sources of information [for project Heat]."*- Product manager *Heat*. Finally, in project *Anti-resist*, stakeholder behaviour was collected by using customer contacts and having conversations with them. As the business manager involved in *Anti-resist* indicated: *"We interviewed three of our customers back in 2004, which are the biggest three in this market and cover about 65%, and asked them what their future needs were and how these needs came to light. I can show you the data that reducing rolling resistance due to stricter mandatory standards defined by the European Union is an important customer concern. You can see that it is going on until 2012. We complemented the interview information with doing desk research."*

4.2 Application knowledge

A second market knowledge dimension that was identified is *application knowledge* (Table 3). Application knowledge is knowledge on customer applications requirements in which a new product (potentially) can be used. It can be seen as knowledge focused on the nature of the customer application for the newly developed product. At times application knowledge can be rather technical. Still this should be seen as market knowledge because it is about technical aspects dealt with by customers. While in some projects only one application was analyzed, in other projects employees focused on multiple applications. As a separate knowledge dimension, application knowledge has few precursors in the marketing and product development literatures. The following examples further explicate the concept of application knowledge.

After the market segment trend of increasing engine temperatures was identified in project *Heat*, application developers involved in the project were sent to customers to collect future heat requirements of turbo chargers and air-ducts applications which are part of vehicle engines. These future heat requirements were fed back to the research department of *Heat's* home organization and used as a research target for developing prototypes of the new polymer grade. As the product manager involved in project *Heat* explained: *"We already had running business in these applications [turbo chargers and air ducts]…we identified a market trend and asked our application developers to visit OEMs to identify future application requirements….Further in the project the OEMs also did application tests. Results from these tests were shared with us."* In project *Green* a main application for the chemical

Table 3 Application knowledge

Project	Application	Examples
Heat	1. Turbo-chargers 2. Air-ducts	"We already had running business in these applications [turbo chargers and air-ducts]...we identified a market trend and asked our application developers to visit OEMs to identify future application requirements." *Product manager*
Green	Epoxy resin	"For the business plan, we also gathered information on developments in the epoxy resin application." *Business development manager*
Diffuse	License plate system	"During the development phase of the project we had learned that our customer had more difficulties with creating the transparent license plate than with creating the lighting unit." *Product manager*
Anti-resist	Rolling resistance in tires	"In the development phase when we worked together with customers, it occurred to us that rubber tires are complex compounds with several ingredients. It is not one product that is mixed with our product, and then there is also the way of mixing that can cause differences in rolling resistance test results." *Project manager*
Foam	1. Aircraft luggage bins 2. Aircraft galleys 3. Aircraft lower wall panels	"With individual validation partners I moved from a market segment level to an application level...I gathered the customer requirements on aircraft interior components in which foam core material was used, such as luggage bins and galleys, and continuously kept customers informed and involved throughout the program." *Marketing manager*
Additive	1. Polymer chain extension in plastics 2. Flow modifying in plastics 3. Dispersing in plastics	"After feedback from a potential development partner, our team converged to the polymer chain extension application having tremendous value for customers." *Senior research associate*

ingredient was epoxy resin. Project members in this project gathered information on developments in this specific application which were used in product development decisions. In *Diffuse*, project members collected information on the specifics of a newly developed license plate system developed by the potential customer. In project *Anti-resist* project members learned about 'rolling resistance in tires'. As the project leader indicated: *"We already sold products that are used in tire reinforcement, but this application was new to us. This is quite exciting because we do not disturb our current tire application. Market segment is still tires, but it is a new application in the tire market. Application requirements for rolling resistance were hard to pin down, but in interaction with us customers shared certain expectations, which, eventually, we could meet with our new product."* In *Foam*, project members gathered application requirements on several aircraft interior components such as luggage bins, aircraft galleys, and aircraft lower wall panels. During the project there was constant interaction on the specifications of these applications between *Foam* project members and potential customers. Also in project *Additive* application knowledge was gathered. Project members discovered new applications while collaborating with potential buyers. Initially, they had thought of *Additive* as a product to improve the flow of plastics, but testing in the market revealed that other applications were far more interesting. As the business manager explained: *"We received market feedback with unexpected results: this is not a plasticizer, this is a dispersant. Our people did not know what a dispersant was or what you disperse, it was a little bit shooting in the dark."* After this discovery the *Additive* team focused on the newly discovered application and gathered more

information on 'dispersing in plastics'. Additionally, the team discovered other applications which resulted in new information inquiries such as 'polymer chain extension in plastics'.

Generating application knowledge often comes down to interactions with customers or potential customers, mainly in the development phase of the product innovation project. As the head of new business development involved in *Diffuse* explained: *"My colleague had a very close relationship with [customer] to develop this license plate system. In this relationship, knowledge on the application was created."* The same practice was observed in project Foam. A quote from the project manager of this project illustrates how important it was to discuss application knowledge with partners that may be future customers: *"I would say that commercially we did a good job. We selected six validation customers which was enough to discover most of the requirements of the [aircraft interior components] applications…we dealt with them with a fair amount of personal contact."* In project *Additive* customer interaction on application knowledge even resulted in a joint patent: *"Our [Additive] team managed to get very close with potential customers. We had either partnerships, joint developments, or close relationships. On the polymer chain extension application this even resulted in a joint patent between our company and the potential customer."* - Senior research associate *Additive*.

4.3 Product usage knowledge

The third market knowledge dimension we identified is *product usage knowledge* (table 4). Product usage knowledge refers to knowledge on how a product is used by customers and how a product behaves in downstream

Table 4 Product Usage Knowledge

Project	Product usage	Examples
Heat	New grade of engineering plastic	"Because we only did internal testing with the new grade [of engineering plastic] we were in need of real life tests with customers. Feedback of these tests was used to adapt prototypes." *Product manager*
Green	New chemical ingredient	"We started sending some samples in advance from the pilot plant in 2006 to check if we were not making mistakes." *Business manager*
Diffuse	Existing grade of engineering plastic	"They [the customer] needed our product in a specific shape, so we produced sheets and laser-cut them in specific shapes…There were several interactions between us and the customer to come up with the right product." *Business developer*
Anti-resist	New grade of fibre	"We tested our prototype products with customers and they thought it was very attractive. However they also discovered some limitations. Based on that feedback we adapted the product and generated a second product and it is expected that this is going to be the main version of the product." *Project manager*
Foam	New type of high performance foam	"Working with several validation partners was quite important. They tested initial prototypes of the material to see if it would meet their set of requirements and fed their experiences back to us…We were open to them, showing them how we developed it and the different test methods that we used." *Marketing manager*
Additive	Existing polymer	"In the beginning we had low molecular weight additives, which are typically used as solvents, dispersants, or flow modifiers. A little bit different but the idea is the same: getting lower polymer weight, lower viscosity, and better flow..then the team made a sample that increased viscosity, so the opposite approach. That was what customers really loved, they really could use that." Business manager

manufacturing processes. For instance, if an organization has a long history of selling a specific engineering plastic it probably has developed deep knowledge on how this product behaves in downstream manufacturing processes. In contrast, if a product is under development there is a limited product history and the organization has limited product usage knowledge. It has to develop this knowledge by engaging in customer tests in the course of the product development trajectory. Product usage knowledge is distinct from application knowledge. In one product development project an organization may target applications that are familiar to the firm with a new product or technology. In this case the organization already has significant application knowledge and limited product usage knowledge at the start of the project. In another project, in contrast, the organization may use an existing product or technology to target unfamiliar applications. Product usage knowledge too has few precursors in the marketing and product development literatures. The following examples further illustrate the concept of product usage knowledge.

The grade development trajectory of project *Heat* consisted of several rounds of technical testing and dealing with issues of manufacturability. This trajectory brought the number of polymer recipes down from about 25 to two. However, the new grade was then still not tested with customers. Although the research group wanted to do more internal tests, the product manager insisted on testing the remaining recipes with customers. *Heat's* project team managed to develop collaborations with several engine part producers and two European automotive OEMs[2]. These downstream partners tested the remaining recipes by using small amounts of the new product in their manufacturing processes. Test results were shared with *Heat's* project members and this product usage knowledge was used to refine product prototypes. In project *Green* the organization had to build a new plant for manufacturing the new product. From the moment the pilot plant was capable of producing a product that came close to the desired end product, project members started sending samples to customers for testing purposes. The feedback on these tests allowed project members to refine the initial product until it was ready for market introduction. As was indicated by the business manager involved in project *Green*: *"We started sending some samples in advance from the pilot plant in 2006 to check if we were not making mistakes."* Also in project *Diffuse* there were several interactions between project members and the customers to generate product usage knowledge which could be used to come up with the right product for the application. In project *Antiresist* generating product usage knowledge even led to the development of a second product which was being deployed next to the original product and is expected to become the main version of the new material. *Foam* project members had discussions with a restricted set of six launching customers that all tested different grades of the new foam material during the development phase of the product development trajectory. Discussions with these partners were quite open and after generating product usage knowledge, this knowledge was used to refine initial prototypes. As the marketing manager involved in project *Foam* explained:

"*Working with several validation partners was quite important. They tested initial prototypes of the material to see if it would meet their set of requirements and fed their experiences back to us…We were open to them, showing them how we developed it and the different test methods that we used."* This product usage knowledge was totally new to *Foam* project members. Normally they talked about plastic materials with validation partners and now they were discussing a foam product. Again the marketing manager explains: "*The type of discussions we had with customers was completely different from what we normally have. It is not an injection moulding material. We did not talk about mould temperature, conditions of raw materials or flow lines."* In project *Additive* different product samples were tested and based on the product usage knowledge that was generated, project members discovered additional product properties that gained a lot of customer interest: *"In the beginning we had low molecular weight additives, which are typically used as solvents, dispersants, or flow modifiers. A little bit different but the idea is the same: getting lower polymer weight, lower viscosity, and better flow….then the team made a sample that increased viscosity, so the opposite approach. That was what customers really loved, they really could use that."* - Business manager *Additive*.

Practices to generate product usage knowl-

2) OEM = Original Equipment Manufacturer. In the context of the automotive industry OEMs are, for instance, Volkswagen and Renault.

edge were comparable with the practices identified to gather application knowledge: interactions with customers or potential customers, mainly in the development phase of the product development projects. In project *Heat*, for instance, project members had interacted with customers for testing prototypes: *"We were able to use our product development partners to get market feedback during development. We had a really good collaboration with them when we were testing prototypes. We had contact with them every 1.5 months."* Another example comes from project Anti-resist where the business manager involved in the project told about interactions with customers to generate product usage knowledge: "*We collaborated with a number of customers, using a secrecy agreement. We had our prototypes and asked them to have a look at them....we already tested the product on lab-scale but then we could say we were testing the product in real tires.*"

4.4 Customer knowledge

We call the last market knowledge dimension *customer knowledge*. This knowledge dimension does not refer to customer needs and wants, which is predominately captured by application and product usage knowledge, but to additional useful information about

Table 5 Customer knowledge

Projekt	Customer	Focus area(s) / Examples	
		Contact information	Decision making unit
Heat	1. Tier 1 engine part manufactu-rers 2. Automotive OEMs		"We know who is most important in this market segment, so internally we selected a set of potential partners. Then we convinced the decision makers to work with us on the project." *App. development manager*
Green	Epoxy resin producers		"We learned that some of our customers, for example in the aeronautics value chain, have longer qualification and decision processes than others." *R&D manager*
Diffuse	Traffic safety solutions OEM		"At the start [of the project] I visited this guy [at the customer]. His project was not really serious. He had a small laboratory and was working with students. However at a certain point in time I learned that this organization really wanted to commercialize the license plate system." *Business developer*
Anti-resist	Tire manufacturers	".....we found out that the fibre people at our customer did not really understand our new product. These fibre people put us in contact with the materials group of their company that could better understand our new product." *Business manager*	
Foam	1. Foam cutter 2. Aircraft interior component OEMs	"The reality is that customers who use our thermoplastics for injection moulding are also potential customers for the foam form as well. So we know all about them and the contacts were already there." *Marketing manager*	
Additive	1. Plastic producers 2. Plastic recyclers	"In the following months we tried to generate contact information on all major plastics companies in North America, Europe and Korea." *Senior research associate*	

customers. Customer knowledge too has few precursors in the marketing and product development literatures. With respect to customer knowledge, project member search was mainly focused on *contact information* of existing and potential customers, and the customer's *decision making unit* regarding the adoption of new products (table 5).

Good examples of generating and integrating customer knowledge and focusing on contact information were found in projects *Anti-resist, Foam*, and *Additive*. Within project *Anti-resist*, tire manufacturers were considered as customers for the product under development. Employees working on this project already had contacts at these tire manufacturers because *Anti-resist's* home organization already supplied yarn for tire reinforcement. However, it appeared that these contacts did not have the knowledge to work on par with the *Anti-resist* team. Then these existing contacts looked for other R&D groups in their company that where more familiar with the rolling resistance phenomenon and provided the *Anti-resist* team with contact information. Thus, project members were referred to new R&D contacts at existing customers. As the business manager involved in project *Anti-resist* explained: *"First we called our new product 'modified fibre' but we found out that the fibre people at our customer did not really understand our new product. These fibre people put us in contact with the materials group of their company that could better understand our new product."* In contrast, team members in project Foam used existing contact information in the product development project: "*The reality is that customers who use our thermoplastics for injection moulding are potential customers for the foam form as well. So we know all about them and the contacts were already there.*" - Marketing manager *Foam*. In project *Additive*, team members could not use existing customer contact information for reference purposes or for direct collaboration. Because they did not have contact information of customers in the relevant market segment, they had to search for this information. The main knowledge generation practice used for this purpose was desk research. As the business manager involved in *Additive* explained: "*Initially it was paperwork….buy a market study on low molecular weight polymers and what plastics they are going into. Then you pinpoint the producers of these plastics and look on the internet if you can find contact information."*

Next to contact information, knowledge was generated on the customer's decision making unit regarding the adoption of new products. Also this knowledge was used in new product decision making. Good examples of generating and integrating customer information that focused on the customer's decision making unit are provided by projects *Heat, Green, and Diffuse*. In project *Heat*, project members were already familiar with the automotive 'under the bonnet' segment because the products of *Heat's* home organizations had been used in this segment for over a decade. They had contacts at several engine part manufacturers and automotive OEMs and used these to identify decision makers at these downstream parties. Subsequently, they were able to convince these decision makers to work with them on the project. By working together with epoxy resin manufacturers, project members involved in *Green* found out that decision makers in the aeronautics value chain wanted more tests than decision makers at customers in other value chains before they made the decision whether or not to adopt a new product. As the R&D manager involved in Green explained: "*We learned that some of our customers, for example in the aeronautics value chain, have longer qualification and decision processes than others.*" Using this information led to Green project members paying less attention to the aeronautics value chain and focusing on other value chains to speed up commercialization of the new product. If the application is both new for the product developing organization and the customer, as in the case of project *Diffuse*, and the development organization is not sure they are pursuing a significant opportunity, information on the decision making unit can bring some assurance: "*At the start [of the project] I visited this guy [at the customer]. His project was not really serious. He had a small laboratory and was working with students. However at a certain point in time I learned that this organization really wanted to commercialize this license plate system. At that time we could see it as a true development project.*" - Business developer Diffuse.

5 Discussion and Conclusions

In this study we offer a comprehensive and empirically derived framework of market knowledge as used in successful product innovation of firms operating in the chemical industry. This framework can be used for theoretical analysis as well as for practical purposes.

Based on a qualitative analysis of six innovation projects we agree with a group of scholars (Kusonoki et al., 1998; Turner and Makhija, 2006; Winter, 1987; Zander and Kogut, 1995) that knowledge is a complex resource incorporating multiple dimensions linked to the decision situation at hand. Research in marketing and product development tends to see market knowledge as consisting of customer need knowledge and segment knowledge. The present study shows that this distinction ignores other important market knowledge dimensions. At least in the context of product innovation in the chemical industry four dimensions can be distinguished: *segment knowledge, application knowledge, product usage knowledge and customer knowledge.*

Segment knowledge is market knowledge on parts of the overall market environment, involving the aspects segment size, segment growth rate, and stakeholder behaviour. This market knowledge dimension has some precursors in the marketing and product innovation literature (see e.g. Adams et al., 1998; Jaworski and Kohli, 1996; Veldhuizen et al., 2006). Regarding the dimension of customer need knowledge as used in most of the marketing and product innovation literature our study suggests that it can be refined by adding the independent dimensions of application knowledge and product usage knowledge. This refinement can directly be linked to focusing our research on the chemical industry. The majority of scholarly inquiries in marketing, and also a lot of studies in product innovation, build on compiled empirical data from a variety of industries. These studies fail to capture the idiosyncratic nature of individual sectors. Products from the chemical industry are specific in several aspects (Musso, 2005). This specificity, presumably, impacts the importance of market knowledge dimensions in product innovation. For instance, products in the chemical industry come early in the value chain. They are often very versatile and can be used in far more different applications than end consumer products. While a washing machine can be used for washing clothes, a plastic resin, for instance, can often be used in applications ranging from plastics bags to skis back to vehicle parts. Therefore, the choice of application and the acquisition of appropriate application knowledge are far more prominent in product innovation in the chemical industry than in the development of consumer goods. Finally we identified customer knowledge which is about customer contact information and information on the customer's decision making unit. This last knowledge dimension is seldom discussed in empirical studies in marketing and product innovation which include consumer products. Most probably due to two differences between consumer markets and business markets (Kotler, 2003). First, in business markets there is often a relatively closer relationship between buyers and sellers of new products. Second, in business markets typically more people from the buying organization influence the adoption of a new product. These two characteristics probably make customer knowledge far more relevant in business markets than in consumer markets.

The findings of this research can be used in both academic research and in practice. The framework of different market knowledge dimensions in product development of chemical firms can be used by scholarly researchers as stepping stone to identify additional characteristics of product innovation in this industry. For practice, the framework can be used as a guideline for designing product innovation and marketing strategies. Because of the relatively tacit nature of market knowledge and its distribution across functional departments such as sales, marketing, and application development (Webster, 2002; Workman, 1998), market knowledge often is less obvious and hard to identify. Our framework can help managers to map market knowledge resources and develop market knowledge typologies. Subsequently these typologies can be used as guideline for looking into the future. For instance, when developing strategies or reviewing initiatives that emerge bottom up, managers could classify innovation options by assessing the degree of fit with market knowledge resources that already reside in the firm. In doing so, it can be assessed what knowledge resources are already in place and 'only' have to be updated and what knowledge resources have to be developed from scratch. Subsequently, based on these insights, market knowledge needs can be mapped during the development of a new product and project implementation can be assessed. Finally, the framework can help to match innovation processes with innovation project characteristics in order to increase product innovation performance (see also Smits, 2010).

6 Suggestions for further research

This research can be extended into several directions. Since our study was retrospective

it might suffer from cognitive biases and impression management (Huber and Power, 1985). For instance, with retrospective studies there is a tendency to filter out events that do not fit or that render the innovation story less coherent (Poole et al., 2000). Although we took several measures to minimize these risks, additional research which includes real-time analyses may further reduce these. As proposed by Leonard-Barton (1990) such studies could combine retrospective results with real time product innovation cases to better observe the process as it unfolds. Additionally further research may want to test the effect of generating and integrating market knowledge on product innovation performance of chemical firms. Are some market knowledge dimensions more important than others, and do firms that focus on a wide variety of market knowledge are more successful than firms that take less market knowledge dimensions into account? Also, because our research focused on market segments and direct customers, further research could look further down the value chain and look into the relevance of value chain knowledge as being important for innovation. Finally, an obvious topic for further research might be to map other knowledge resources in product innovation of chemical firms such as, for instance, technological knowledge. Plausibly, a distinction between product and process technological knowledge could be found (Barnett and Clark, 1996; Pisano, 1997).

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Journal of Business Chemistry

Practitioner's Section

Pricing in the crisis? An empirical analysis

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In an empirical survey on pricing, team steffenhagen GmbH analyzed the impact of the financial and economic crisis 2008 / 2009 on the chemical industry.
80 pricing managers gave insights into the effects of the crisis, the concernment triggered by the crisis and the counter measures that were employed in the companies.
The analysis uncovers success factors which promise successful pricing in times of crises. These include, among others, a high pricing performance already before the crisis, a clear structure of the pricing processes, a result-oriented alignment of the pricing, a good knowledge of the advantage of the own products in the processes of the customers and in the competitive environment, as well as pro-active pricing approaches. During the crisis, it is vital to gain more information on the financial situation of the customers to substantially invest in marketing and distribution, to limit abatements, and to ensure professionalism in pricing despite the turbulences of the crisis. In summary, these factors denote sufficient reasons for an increase of professionalism of the pricing.

Background

Shortly after the first outcomes of the collapse of prices in the American real estate market in February 2007, it took about 1.5 years until the crisis left perceptible marks in the real economy and with that also in the chemical industry. Sales and profit collapsed, productions were closed down, and reduced working hours were the often documented consequences.

Although it remains unclear whether the crisis is over, many indicators point upwards. As an example, the orders of industries not directly linked to the automotive sector are increasing. Temporarily shut down chemical plants resume production at an increasing rate and the association of the chemical industry in Germany (VCI) expects a 5% production and 6% sales growth rate for 2010.

On the other hand, it is still a long way until the high values of the first half-year in 2008 will be in reach, and there are already new voices who indicate the risk of further bubbles. The weekly German magazine "Die Wirtschaftswoche", for example, has already warned against a new bubble in the Chinese real estate and share markets – induced by trade cycle policies – in December 2009. Regardless of whether the light at the end of the tunnel is only in sight or already reached, the consequences of the financial crisis on the chemical industry were serious, and reason enough for team steffenhagen to investigate the details.

With regard to the financial crisis 2008 / 2009, team steffenhagen's target was to identify arising challenges for companies in the chemical industry and to assess their impact on the firms' pricing strategies. More specifically, the survey illuminated the following aspects in detail:

- Which pricing strategies did the companies have before the crisis?
- Which impact did the crisis have on the companies' pricing strategies?
- How did the companies react?
- What can we learn from the crisis in terms of pricing?

The way into the crisis

In February 2007, the break in US-American real-estate prices left its first traces: The HSBC Bank in London had to release the first profit warning in its history because of the multi-million loan default of the US-daughter Household. Two weeks later, US-Boss Bobby Mehta lost his job because of this development. Hardly anybody suspected yet one of the biggest world economic crises was ringed in.

US-Finance Minister Hank Paulson only talked about „limited credit problems". In May 2007, also the Federal Reserve Chairman of the US Ben Bernanke was sure about the crisis to be limited to the American real-estate market.

How wrong he was became clear in July 2007, when the IKB (Deutsche Industriebank KG) in Germany was hit, and the KfW bank group had to bail for 8.1 billion Euros, while Bear Steams in the USA had to announce two of its hedge funds as worthless. The customers of the British investment bank Northern Rock emptied their accounts in August 2007, until the British government declared to guarantee for the deposits.

In 2008, the crisis reached the real economy, and thus, the chemical industry. On January 21st, the DAX lost seven percent in only one day. Seven months later, also the biggest chemical enterprise BASF SE gave warning of hard times. Contemporaneously with the insolvency of Lehman Brothers, BASF cut back the plastics production to fight against the crisis. Likewise, Rhodia closed a polyamide plant in Italy as part of a huge cost reduction program. Besides Dow that proclaimed the recession in October 2008, several chemical companies in the US reduced their profit expectations.

The financial crisis turned into a world economic crisis. After the automotive sector was hit first, the automotive supplier industry was next. In December 2008, TMD Friction was the first German automotive supplier to apply for insolvency – the new car sales in Germany collapsed by 25%.

To cope with the crisis, the chemical industry sought to cut back labor costs through reduced production, as for example Bayer or Lanxess, or by means of staff reductions, e.g. Du Pont. In January 2009, Lyondell-Basell got into financial difficulties, whereas BASF sent 1800 employers into short-time work. In February, the association of the chemical industry in Germany (VCI) even referred to a catastrophe.

Just after the first glimpses of hope seemed to rise in July 2009 and – in accordance to Financial Times Germany (09.07.2009 and 22.07.2009) – reliance came back to the chemical industry, DSM already called the boom into question in August 2009. Süd-Chemie confirmed the negative perspective, too.

However, in September optimism became accepted on a broader base. For the year 2010, the VCI, as mentioned in the beginning, expected a production growth rate of 5% and a sales growth rate 6%, even if it has been assumed on a low base level.

The survey was conducted in the chemical industry by team steffenhagen during the summer of 2009, i.e. between the first boom tendencies and the relapse into negative perspectives. So the shock from the crisis was still enormous, but, dependent on the industry sector, the first glimpses of hope were observable.

The survey

In 2005, team steffenhagen was able to uncover many weaknesses in the pricing management of companies, who participated in a first pricing survey focused on the chemical industry. In the current survey, again 80 pricing managers from different segments of the chemical industry gave response to our questions.

The participants of this survey mainly worked in the marketing and sales department, representing companies and departments of all sizes with different application areas of chemical products, such as petrochemistry, plastics, automotive, construction, or nutrition (c.f. Fig.1). Moreover, participating companies were located in different markets, including the specialty market, the commodity market, as well as the so called semi-commodities market (c.f. Fig.2).

It has to be noted that, although the survey indeed covers different segments of the chemical industry, it cannot raise the claim to be representative. It seems obvious that the evaluations presented in the survey show an image which is slightly distorted into a positive direction of the crisis and its consequences.

The following figure highlights the distribution of participating firms with regard to size and business types.

Figure 1 Structure of the participants by industry branches

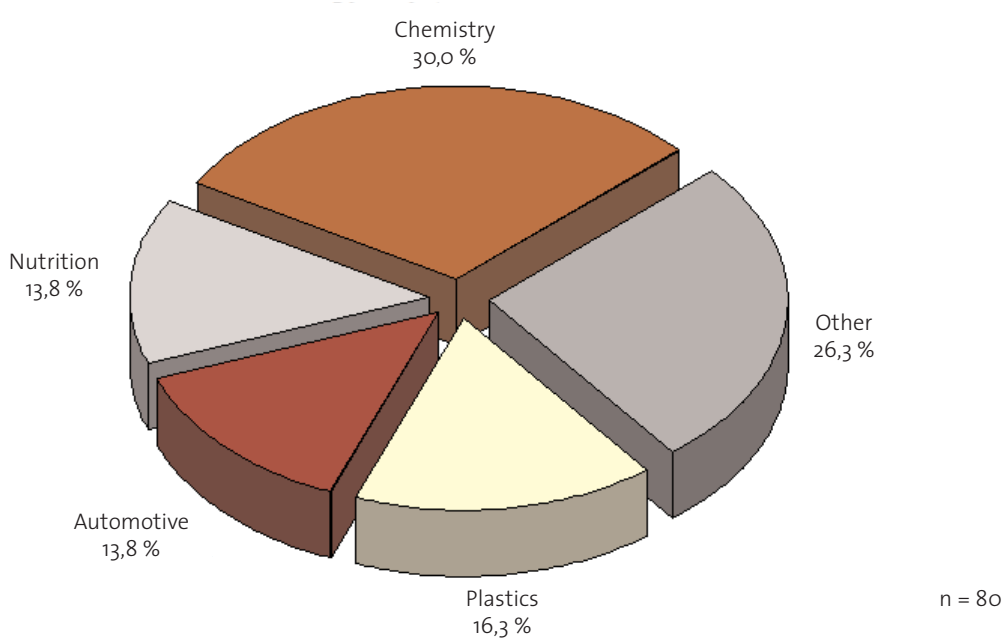
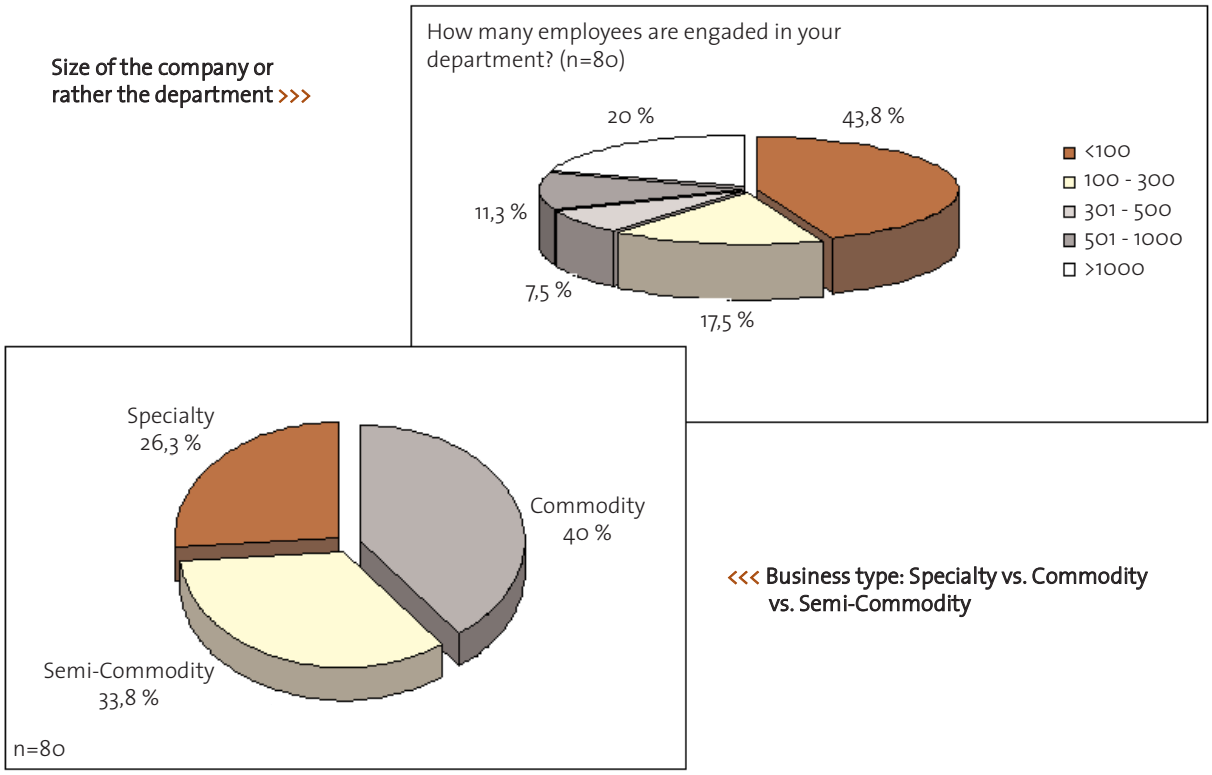


Figure 2 Structure of the participants by number of employees and business type



Pricing before the crisis

In their self-evaluation, the participants provide a clear picture in terms of their pricing behavior: About three quarters of them indicated to have implemented both transparent pricing processes and clearly defined pricing strategies.

It is precarious though that nearly 70% of the participating companies (and departments) still gear their pricing towards maximum EBIT.

That implies that the majority of companies are still in danger of taking pricing decisions on the basis of overhead costs.

This apprehension is supported by the survey: For about 50% of the companies the overhead costs are crucial for price decisions to a high degree. This is an approach that verifiable leads to wrong decisions! Only for 12% of the companies the overhead costs play a merited minor role.

One can find a strong orientation towards sales volume or market share within 15% of the companies. As expected, the suppliers of semi-commodities and commodities are overrepresented here.

Furthermore, it attracts attention in the analysis of the survey that the competition orientation comes off badly in terms of pricing. Only 36% of the interviewees claimed that before the crisis they used systematic methods for competition analyses.

Before the crisis, a strong orientation towards the competitors' prices was crucial for barely a quarter of the interviewees. That would have been plausible for specialties, but it is precarious that even with commodities not more than a third of the involved companies are using systematic competition analyses. However, 45% of the commodity providers try to anticipate the reactions of competitors when setting their prices.

Moreover, a quarter of the interviewees revealed no competitor orientation regarding the pricing before the crisis.

In terms of customer orientation the situation was better before the crisis, although further optimization is essential. 60% of the interviewees had a good knowledge of the benefits of their products in the processes of their customers before the crisis. The least knowledge about the value in the processes of the customers could surprisingly be observed in the specialities market (48%).

Because of the weaknesses associated with competitor orientation, only 50% of the interviewees – according to their own statements – had a good knowledge of the customer value at their disposal compared to their competitors.

The orientation of the prices towards the provided customer value was found in 45% of the participating companies. However, only 17% were able to quantify the customer value before the crisis. Regarding the specialty providers, there were only 10% able to do so. Commodity providers revealed – as expected – the lowest orientation of the prices towards the customer value as well as the lowest efforts to quantify the customer value.

In the same way, there was already before the crisis the need to implement the customer value in price negotiations: Less than 50% were able to demonstrate the customer value in price negotiations before the crisis. Only for 38% the customer value was at the core of their price negotiations.

In terms of the price implementation, it is striking that around 60% of the companies were well prepared during the crisis regarding existing pricing competences and argumentation support for the sales people. But despite all that, the targeted price was achieved only by a third of the companies, and particularly specialty providers seem to have difficulties here.

Only 35% of the interviewees reported a proactive pricing before the crisis. Apparently, this is much easier for specialty providers, of which nearly the half realized a pro-active pricing already before the crisis.

Regarding price controlling more than 85% of the companies used systematic and established tools before the crisis. When asked about specific tools, interviewees named only rarely established tools like price scatter plots or profitability calculations. They mostly emphasized general analyses and tools, for example data bases and benchmarking.

So it is not very astonishing that only 40% of the interviewees claimed to be able to prepare better price decisions thanks to specialized tools before the crisis. Even the impact of pricing decisions on the own performance is perceived positively only by 56% of the companies.

A kind of oath of disclosure regarding the price consciousness was revealed in the end of the survey. The participants were asked for the biggest lever for the financial result and they could choose between the price, the variable costs, the fixed costs, and the sales volume. Surprisingly, only 35% were right and named the price.

Against the background of these mediocre results in terms of pricing quality, the following

questions have to be asked: To what extent did the crisis negatively affect the companies? And, which companies were eminently hit and why?

The impacts of the crisis

Immediate impacts of the crisis

Certainly, the primary impact of the crisis was the customers' reluctance to buy. Declining demands and quantities of sales are on the 1st place of our survey in the "charts" of the distinct changes contingent upon the crisis. More than a third spontaneously thought of this when they were asked for the clearest changes caused by the crisis. In terms of internal consequences, on the contrary, the focus on costs remains unchallenged on the first place (11%).

Both facts are not very remarkable. Elsewhere it was reported that sales collapsed by 50% (or in single cases even up to 80%) and that cost cutting programs were at the top of any firm's agenda. Because of this development more than a third of the interviewees assessed themselves as being highly affected by the crisis. A quarter of the participants were on the contrary only weakly affected (cf. Fig.3).

The companies that were according to their statements strongly affected by the crisis likewise felt strongly insecure regarding the own financial situation. About 42% of them noticed in this regard an increase in uncertainty since the beginning of the crisis. Contrasting this, more than 50% of the less crisis-affected companies felt substantially less insecure. The uncertainty has strongly increased since the beginning of the crisis, especially for commodity providers. (Annotation: the subjective concernment was measured as an approval to the statement "Our company is strongly affected by the current economic crisis" on a six-point rating scale. The answers were clustered into "weakly affected", "moderately affected" and "highly affected".)

An increased uncertainty in the judgement of the financial situation of the customers, which was detected by nearly all the participants, has to be added. Specialty providers, however, seem to assess the situation a bit better.

Another effect of the crisis can be led back to the considerably stronger fixation of the negotiation processes on the price, especially at commodities and semi-commodities. In this regard increasing efforts are undertaken to convince the customer of the added value of the own products.

The implementation of a successful pricing in and despite of the crisis is therefore achieved especially in companies which were only slightly affected by the crisis: While 75% of the

Figure 3 Subjective concernment by the crisis

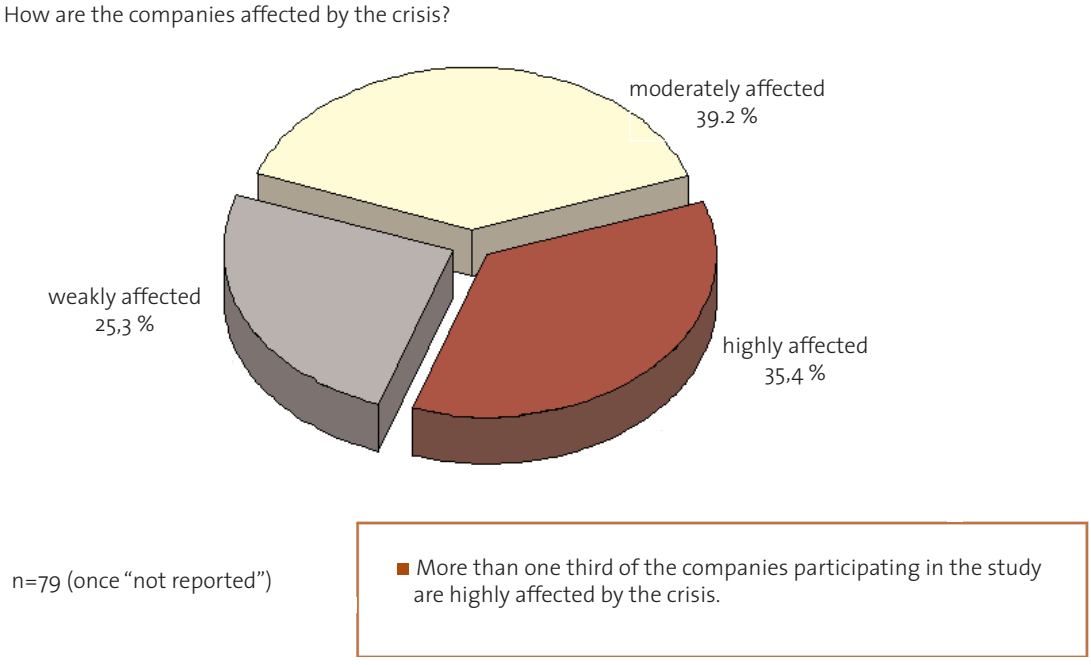
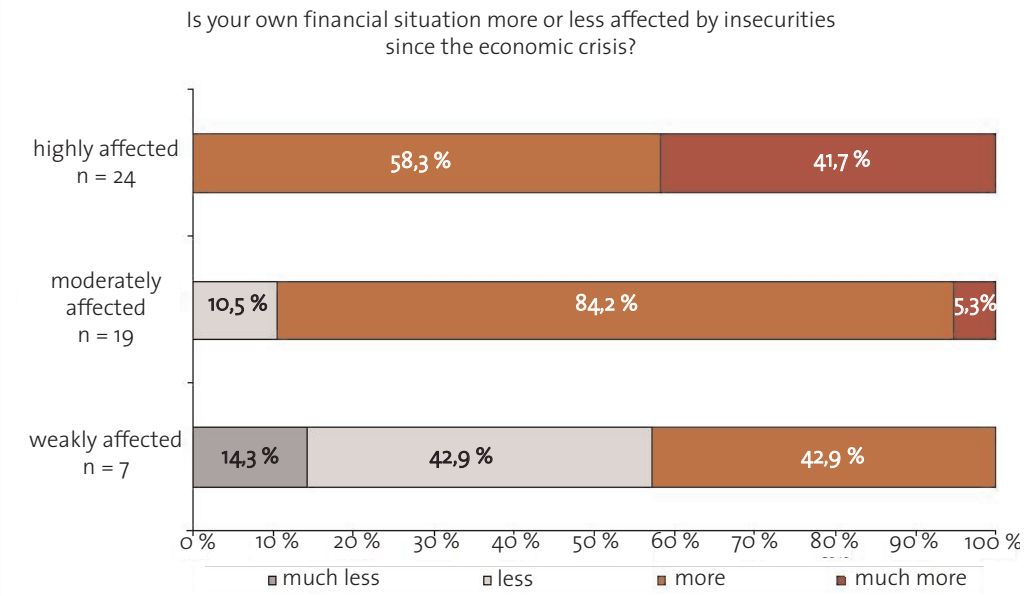


Figure 4 Insecurities about the own financial situation in dependence to the concernment by the crisis



weakly affected companies implemented a successful pricing, the ratio decreases for highly affected companies to a maximum of 50%. In regard to the type of business, it is remarkable that commodity providers reveal the most difficulties. However, 44% of them believe that they have a successful pricing in the crisis.

A vicious circle is initiated. Especially not well-prepared companies regarding the pricing will be affected by the crisis. The concernment is illustrated by greater uncertainty about the own situation and the situation of the customers. If this uncertainty is followed by a stronger price fixation resulting from incompetent acting on the market, the concern will increase even more. Accordingly, successful pricing will be impossible and, in turn, the sensitivity of firms against crisis-induced threats will increase. Against this background, an accurate overview of the factors, which increase the concernment and in the worst case denote first the step into this vicious circle, are worth it.

Therefore, the question arises which factors lead to a higher or high concernment.

Where and when is the concernment eminently high?

The diversification of the concernment into industry sectors was expectable. We could find high concernment especially in companies which supply the automotive sector as well as the plastic sector. Following the motto "people will always eat" we find only a slight concernment in companies with customers affiliated to the nutrition industry.

Surprisingly clear was the difference between specialty and commodity or semi-commodity providers. Only 14% of the specialty providers are strongly concerned, while the share runs up to 38% for semi-commodity providers and up to even 48% for commodity providers. Especially a high market transparency and low differentiation ability seem to be the driving factors which make them vulnerable to the crisis.

Since less concerned companies can be found in the less price-driven sectors, we conclude that less price-driven industries denote a solid market even in the crisis.

Which countermeasures did the companies in the chemical industry employ to protect themselves from the effects of the crisis?

This question will be pursued in the following for the different phases of the pricing process (cf. Fig. 5).

Which countermeasures were employed?

Countermeasures related to costs and information procurement

The reduction of costs is one of the first crisis-induced reflexes. The following means to reduce the costs were used intensively:

- Stronger focus on production costs: 95% of the participating companies have urged their efforts to optimize the production costs since the beginning of the crisis. A third of the interviewees even reported strongly enforced measures.
- More pressure on the commodity prices: There is no exception here. The crisis induced all companies to increase the pressure on their suppliers to reduce commodity prices. Remarkable strong pressure was exerted by providers of commodities and semi-commodities.
- More pressure on payment terms: More than 72% also employed shortened periods of payment, which increased the burdens on the suppliers even more. Especially commodity providers are not very willing to compromises.

Contrasting cost related saving effects, investments in information procurement are vital. The following investments were enforced since the beginning of the crisis:

- More market intelligence / market observation: All participating companies conduct more market observations since the beginning of the crisis to reduce existing uncertainties. There are also no companies which have not enhanced observations of the competitors.
- All interviewees are using more external information sources since the beginning of the crisis to be able to more reliably estimate the financial situation of their customers.
- More resources in marketing & sales: While a third of the companies are saving their money, two thirds invest more into marketing and sales than before the crisis.

We also detected a polarization of companies with regard to the investments in technical staff. While slightly more than half of the companies tend to reduce investments in technical staff, the "smaller half" tends to expand their investments.

Strategic countermeasures and measures of base price decisions

Due to the crisis, participating companies are now comparatively more oriented towards their competitors, they have enforced the structuring of their pricing processes and they conclude contracts with shorter durations:

- Increased competitor orientation: Since the beginning of the crisis more than 80% of the interviewees orientated their price decisions more towards their competitors.
- Enforced structuring of pricing processes: Three out of four companies have enforced the structure of their pricing processes since the beginning of the crisis. Every forth company even indicated a considerably higher structuring.
- Shorter contract duration (especially at commodities): Overall, more than 85% of the interviewees rely on shortened contract durations. With reference to commodity providers, now even 95% employ shorter contract durations.

Regarding the question, if companies have parted from unprofitable business segments in consequence of the crisis, we once again identified two groups.

Measures at pricing decisions

The following reactions were apparent regarding pricing decisions:

- In correspondence to the tendency of shorter contract durations, more than 80% implemented more short-dated price alignments since the beginning of the crisis. This tendency is very high for commodity providers and companies with a low pricing performance. (Annotation: The pricing performance was deduced as an indirect indicator out of different questions of the questionnaire.)
- More than 75% reacted on the crisis by means of more price reductions to keep up the sales volume. Even if this reaction is rarely employed by specialty providers, this reflex has to be scrutinized critically:
- On the one hand the outstanding importance of the price advises caution.
- Furthermore, the question arises, if the resulting price wars are grounded on a real demand in times of the crisis-induced decrease of needs. Does it make any sense to fight with reduced prices for a demand which does not exist anymore?
- Besides that, price reductions can be easily

copied by competitors. While price wars are often initiated by price reductions, firms often employ this mechanism without a verification, if there is a realistic chance to win based on the own costs position, and with fatal consequences for the own profitability.

- On the other hand, nearly 25% of the queried companies are able to enforce higher prices since the beginning of the crisis; even 36% of the specialty providers are able to do so.
- More than 57% of the companies separate the pricing of service features to a lesser extent. On the contrary, other companies reacted by means of an enforced direct pricing of the services.

Measures of price implementation and price controlling

In order to meet the challenge of price enforcements successfully, 80% of the participating companies are using more and more trainings of their own sales employees.

Nearly a third of the companies do not use variable remuneration models that are in line with the price implementation to incentivize sales people. Within much more than a third of the companies, which work with performance-based remuneration models, the performance criteria have no direct connection with the outcome.

92% of the companies, which use more decision supporting tools, rely on a more intense price controlling. However, the question about the professionalism of these efforts remains unanswered.

With all used measures and reactions on the crisis the question about the efficiency arises. Which success factors can be derived for a pricing in the crisis?

Success factors for a pricing in the crisis

A high pricing performance is the best prevention for a crisis

Of course a high pricing performance, per definition, provides the best premises to control the most important outcome driver – the price. This is not very surprising.

The survey proves that a high pricing performance is indeed the best premise to survive a crisis like the world and economic crisis which started in 2007/2008. In conformity with the rule „Prevention is better than cure“, a high pricing performance protects from the effects of the crisis. The amount of companies that were only slightly affected by the crisis is as double as high for companies with a high pricing performance (29%) than for companies with a low pricing performance (14%). And you don't even have to be counted to the best in pricing to prepare well for crisis times. Even companies with a medium pricing performance (26%) are only weakly affected.

A high pricing performance therefore leads to being less affected by the crisis. A low pricing performance before the crisis on the other hand appears to be enforcing the crisis related uncertainties, for example regarding the estimation of the own financial situation.

A high pricing performance allows for successful pricing even in the crisis

Companies with a lower pricing performance are not only hit stronger by the crisis, but they have also more difficulties in or despite the crisis to implement a successful pricing. Accordingly, only 40% of the companies with a low pricing performance are able to implement a successfull pricing, while 55% of the companies with a medium or high pricing performance are able to do so.

Moreover, the companies that reveal a successful pricing even in the crisis are not hit by the crisis that strong. The negative impact of the crisis is further reduced by a successful pricing.

Pro-active and clearly structured pricing strategies are paying off

Our survey emphasizes how important pro-activity is for pricing: With increasing pro-activity the effects of the crisis decline. Highly affected companies claim that their own price behavior is only for 25% distinctly pro-active. Therefore the weakly affected companies indicate a percentage of 45%.

A stronger structuring of the pricing processes during the crisis results in more relief. Only weakly affected companies have more structure in the pricing since the beginning of the crisis. On the contrary, highly affected companies are losing more than 42% of structure in their pricing processes.

Enforcement of the market related activities brings success in the crisis

Companies, which were hit only weakly by

the crisis,

- are using, by trend, more information sources for the assessment of the financial situation of the customers since the beginning of the crisis,
- invest much more into marketing and sales resources,
- orient the prices more towards their competitors since the crisis started,
- are aware of the value of their own products in the competitive environment as well as in the processes of the customers and
- experience much less increase in the competitive pressure than strongly affected companies.

Price controlling and result-orientation. Even in the crisis.

Companies that were only weakly affected by the crisis, enforce the exit from non-profitable deals more than highly affected companies. Crisis-torn companies use more price reductions since the beginning of the crisis, to be able to keep up the sales.

So, it doesn't surprise that among the strongly crisis-affected companies, we find a lot of companies with pricing strategies geared towards the maximization of the EBIT (82% versus 63% of less strong affected companies). The overemphasis of not decision relevant fixed costs leads apparently towards wrong decisions.

The companies however, who were well prepared for price decisions with systematic price controlling, until the crisis began, were hit less hard by the crisis: Only 35% of the strongly affected companies used such a systematic price controlling, while 53% of the less affected companies did so, too.

Lessons learned? What we should learn from the crisis

What you should do right now and therefore before the next crisis

The results of the survey give clear evidence on pricing-related needs for optimization that should be taken seriously.

The survey results suggest how to prepare yourself for the next crisis:

- Care for a high pricing performance already before the crisis! A high pricing performance will substantially reduce the effects of the next crisis.
- Structure your pricing processes! The stronger the structure of the pricing processes, the smaller the effects of a crisis on your processes.
- Align your pricing with the results and the really relevant costs! Consequently use a pricing that is orientated towards the marginal income and avoid grounding your pricing decisions on fixed costs, EBIT or market shares. This also offers you further protection on wrong decisions in the crisis (and, of course, already before the crisis).
- Care for a good knowledge of your own products in the processes of your customers and in the competitive environment! This also will result in less vulnerability in the crisis.
- Focus on pro-active pricing! Pro-active pricing also leads to less vulnerability in the crisis.
- Increase the competitor orientation of your pricing! More orientation on the competitors leads to less effects of the crisis on you as well.
- Focus on a systematic price monitoring and controlling for a better preparation of price decisions! Less problems result in crisis times.
- Finally, care quickly for a systematic professionalization of the pricing, because after the crisis is before the crisis. No instrument has a comparable direct and strong impact on the result than pricing!

What has to be done in the next crisis?

If the next tangible economic or sector crisis knocks on your door, you can derive the following suggestions from our survey:

- Use systematic information sources about the financial situation of your customers in the crisis! Fewer problems will affect you in the crisis.
- During the crisis, invest also or especially more into marketing and sales!
- Be cautious and conservative in terms of price reductions, also in the crisis! More crisis-induced price reductions lead to more impact of the crisis.
- Don't let the pricing performance suffer! Companies, which are even in a crisis able to implement a successful pricing, won't be hit so hard by the crisis.

Conclusion

It is undeniable that the economic and world crisis had and still has a dramatic impact on the

companies in the chemical industry. Decline in sales, shutdowns of production sites, profit setbacks, job cuts and insolvencies didn't spare the chemical industry.

The survey results suggest that the perceived effects were especially high for manufacturers of commodities and semi-commodities as well as for companies who supply the automotive industry.

But the situation is not hopeless at all: Especially a professional price management also in times of crises offers good possibilities to survive the crisis without unnecessary losses.

The survey shows that a high pricing performance indeed protects from fatal effects. The companies, who are able to stick to their pricing even in a crisis, are less affected by it.

A pro-active pricing, a professional price controlling and an enforced supply of the pricing process with information of customers, of their financial situation, and the value of the own products additionally act as a brake on the crisis-related risks.

The consistent optimization of the price management in all stages of the pricing process offers the best equipment for the purpose of prevention to protect yourself from the effects of the crisis, for the purpose of a better and result-oriented steering through the crisis and of course beyond the times of crises, because no other instrument has a comparable effect on the results than pricing.

Therefore implement as quickly as possible a consistent professional price management:

- Value-driven instead of cost-based pricing
- Focus on profits instead of volume or market share orientation
- Pro-active instead of reactive pricing

Unfortunately there are still too many companies – also in the chemical industry – who have not yet implemented these principles and the identified success factors of this survey consistently and consequently. This is also shown by the results of the survey.

The following figure summarizes the systematic pricing process in an overview. At the bottom you can find measures for the different stages of the pricing process.

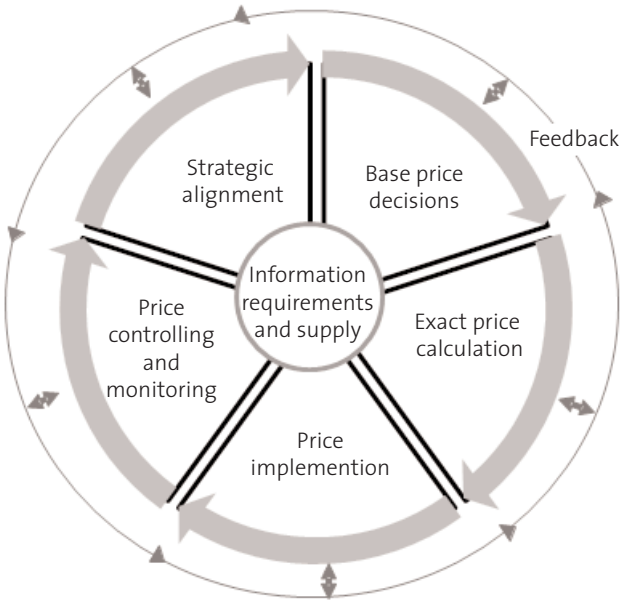
Strategic alignment

- Strategic binding of the pricing
- Clarification of the business model
- Strategic objectives
- Price / Value positioning
- Behavior in cost / performance competition and in the product life cycle

Base price decisions

- Clarification: Value advantage in the compe-

Figure 5 Systematic pricing: The pricing cycle



tition (e.g. PSR2)
- Definition of pricing methods (e.g. Value Pricing, Competitive Pricing, Performance Pricing, price tactics)
- Price definitions
- Pricing guidelines
- Pricing rules

Exact price calculation
- Definition of the price range and price boundaries
- Unit price decisions and transaction prices
- Incoterms
- Price contracts

Price implementation
- Price argumentation and price negotiations
- Pricing and negotiation trainings (incl. MBTI®)
- Roles & Responsibilities
- Pricing processes
- Incentive systems

Price controlling & monitoring
- Price reporting
- Tools for price controlling
- Pricing Toolbox
- Price -, quantities-, and CM-monitoring
- CM-simulator
- Price Scatter Plots (price clouds)
- Customer Box Plots
- Cost Development Calculator
- Waterfall Analyses
- Customer result calculation
- Knowledge Toolbox