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Letter from the Editors

Stay focused in times of complexity

Organizations, particularly within energy intensive industries, are increasingly forced to handle uncertainties that emerge in the course of a changing resource base or the decreasing security of energy supply. Thus, chemical companies are not only confronted with volatility but also face more frequent interactions with various actors within their environment, such as energy suppliers, governments or NGOs, which, subsequently, may increase both the depth as well as the breadth of the firms' network. To improve dealing with these complex settings, factors such as the pursuit of common goals or an improvement of knowledge exchange within these networks appear to be essential. Hence, we are pleased to provide a more fine-grained perspective on these emerging challenges and potential solutions, since the articles of the present issue of the Journal of Business Chemistry refer to topics such as technology transfer, supply chain management, or procurement activities within the chemical industry.

The research paper of the present issue "Technology transfer by new ventures within the chemical and pharmaceutical industry" by Gunter Festel examines the creation of new ventures like spin-offs and spin-outs as a method for technology transfer within or among companies as well as with universities. Using several case studies from the chemical and pharmaceutical industry in Germany and Switzerland, the author deals with different dimensions of technology transfer, such as the technology maturity, the need for additional resources, and the outcome of technology transfer. The author finally shows that the maturity may not directly lead to the commercialization of the technology and, furthermore, the findings reveal that academic spin-offs, corporate spin-outs, and internal start-ups differ regarding the acquisition of additional resources as well as the outcome of technology transfer.

The first paper of our Practitioner's Section "LEAN SCM: A paradigm shift in supply chain management" by Josef Packowski and David Francas provides an overview of key elements of lean supply chain management (LEAN SCM) and its application in process industries. More specifically, the authors refer to LEAN SCM as an alternative approach for advanced planning and scheduling (APS) as well as enterprise resource planning (ERP) systems. Besides outlining three essential elements of LEAN SCM, i.e. cyclic planning with rhythm wheels, end-to-end synchronization along the supply chain, and variability management on the capacity and inventory side, the authors additionally present the improvements that have been achieved with the implementation of LEAN SCM.

In the article "Optimization of economic conditions in the chemical, pharmaceutical and medical technology industry through a stringently interlocking procurement in the holistic business approach", Ivan Barjasic demonstrates possibilities for improving the value orientation of procurement to increase a firm's performance. By conducting a cross-industry study based on evaluating the main influencing factors of successful procurement, such as the underlying strategy, the flexibility of organizing the processes, or the qualification of the staff, the author identifies weaknesses and stresses the need to find a consistent measure for procurement performance. Furthermore, by taking a closer look on chemical, pharmaceutical and medical technology sectors, improving the alignment between procurement and corporate strategy as well as enhancing the efficiency of decision processes appear to be the major opportunities to gain a leading position as "innovative value provider".

In his paper "Classification of chemicals in the commercial area", Kai Pflug emphasizes the importance of reconsidering the choice of classification levels within the chemical industry. Categorization, e.g. of business units or staff positions, is usually performed on the basis of five levels varying from an individual chemicals to an end use perspective. Not only across firms but already within companies various levels are applied. As an overlapping usage results in a complex allocation of responsibilities and reduced exploitation of synergies, the author develops a guideline of how to select the right classification levels.

Please enjoy reading the third issue of the tenth volume of the Journal of Business Chemistry. We are grateful for the support of all authors and reviewers for this new issue. If you have any comments or suggestions, please do not hesitate to contact us at contact@businesschemistry.org.

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Journal of Business Chemistry

Research Paper

Technology transfer by new ventures within the chemical and pharmaceutical industry

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The role of new ventures for technology transfer from universities and research institutions to companies and between companies focused on the chemical and pharmaceutical industry are discussed in this article. Different aspects of this technology transfer approach like the maturity of the technology, the acquisition of additional resources and the technology transfer results have been analysed based on case studies from the chemical and pharmaceutical industry in Germany and Switzerland. Especially established industries like the chemical and pharmaceutical industry rely on effective and efficient technology transfer to maintain their global competitiveness. Academic spin-offs can help to transfer technologies to the industry if further research and development work is out of scope of the academic institutions. Corporate spin-outs are an alternative to closing operations should these no longer fit into the parent organization. For technology transfer, both spin-offs and spin-outs can be integrated into a new parent company or work as service provider. Internal start-ups were identified as a new approach for company internal technology transfer from research departments to business units focused on commercial operations to overcome innovation barriers within companies.

1 Introduction

The European Union has been confronted with a phenomenon called knowledge paradox (Pavitt 2000). The high quality of research at universities and research institutions has not been translated into commercial applications in a sufficient way. Licensing is the established way to transfer technology from universities and research institutions to the commercial sector. But licensing is only applicable when technologies can be protected by patents (Hearn 1981). If the technology is not mature enough to establish strong IP rights, the commercialization of the technology is difficult. Besides licensing, academic spin-offs from universities and research institutions can be used for technology transfer (Franklin et al. 2001). Despite the fact that normally licensing is short-term financially more attractive, the ownership of equity in spin-offs may increase the potential up-side gain and is an attractive option to universities and research institutions. Taking equity in a spin-out company can produce a greater average return in the long run compared to licensing business (Bray and Lee 2000).

This paper investigates the creation of new ventures like spin-offs and spin-outs as a method for technology transfer from universities and research institutions to companies and between companies. Additionally, the approach of internal start-ups for company internal technology transfer, which is not yet described in the scientific literature, was identified during our research. The paper specifically seeks to address the following research questions.

- **RQ1?** How was the maturity of the technologies increased within the new ventures?
- **RQ2?** How were additional resources acquired by the new ventures?
- **RQ3?** Which technology transfer results were achieved by the new ventures?

The chemical and pharmaceutical sectors as mature industries were selected as they rely on effective and efficient technology transfer to main-

tain their global competitiveness. They are globally one of the largest manufacturing industries with strong impact on other industries. The regional focus was on the two countries Germany and Switzerland with a globally very strong chemical and pharmaceutical industry. This regional focus was chosen to have the same general cultural background which makes the analysis of the organizational, managerial, financial and cultural similarities and dissimilarities more reliable.

Section 2 of this paper provides the theoretical background according to academic spin-offs and corporate spin-outs. The methodology is described in section 3, the results and discussions are shown in section 4 and the implications and conclusions in section 5.

2 Theoretical background

2.1 Academic spin-offs

Technology transfer through the creation of academic spin-offs is important especially in high-tech areas (Shane 2002; Heirman and Clarysse 2004; Stam et al. 2009). There has been a substantial increase in the number of academic spin-offs created in Europe (Wright et al. 2004; Moray and Clarysse 2005; Clarysse et al. 2007). This is based on a change in government policies that encourage universities and research institutions to commercialize their research results. Besides teaching and research, it is a mission for universities and research institutions to support economic and social development by commercializing the output of basic research through technology transfer (Etzkowitz et al. 2000; Etzkowitz 2003).

In the United States, the Bayh-Dole Act has granted the institutions, in which research is conducted using governmental funds, ownership of their research outcome in order to support their commercial application (European Commission 2003; Grimaldi et al. 2011). In consequence, the enactment of the Bayh-Dole Act in 1980, accompanied by other measures (Popp Berman 2008), had been substantially enhanced the commercialization of technologies developed at universities and research institutions. In contrast in Europe the legislative counterparts were lagging behind for about 20 years (Grimpe and Fier 2010) and the policy approaches are very heterogeneous (Mustar et al. 2008; Wright et al. 2008). Following the United States model, several European countries adopted comparable policies aimed at encouraging a more active role for academic institutions in technology transfer (Grimaldi et al. 2011) on national level, while other countries have acted in exactly the opposite way. In line with Bayh-Dole, Germany made an equivalent step through the abolishment of the so-called professors' privilege in 2002, which had granted the scientists the right to claim ownership of the research outcome of their scientific work, even if the underlying research was funded by public money designated to the university. In the same year, however, Italy, has newly introduced the professors' privilege. In contrast to these regulations on national level, in other European countries such as the United Kingdom each university has defined its own rules in respect of the ownership of the research results (Czarnitzki et al. 2009).

Founding a start-up out of a university or research institution is a special challenge for entrepreneurs. Normally academic researchers do not have the knowledge, expertise or experience to commercialize their research results (Litan and Mitchell 2007). Therefore, many universities and research institutions have implemented technology transfer offices (TTOs), entrepreneurship centers and incubators (Goldfarb and Henrekson 2003; Bercovitz and Feldmann 2006; Rasmussen et al. 2006). These TTOs recognise start-ups as an interesting method of technology transfer and thus help scientists in their entrepreneurial efforts (Markman et al. 2005; Meyer 2006). It is important that universities and research institutions have clear strategies towards spin-off activities (Lockett et al. 2003). This includes the build-up of expertise and networks as well as the allocation of sufficient resources to realize the strategy in a professional way.

2.2 Corporate spin-outs

Whereas the term R&D spin-off stands for a new company based on the findings of members of a research group from academia, the common definition of spin-out is when a part (department, business unit division or even a project team) of a company or organization becomes an independent business (De Cleyn and Braet 2009; Mustar et al. 2006). But the two terms are not always used unambiguously, as sometimes the term corporate spin-off is used for a small company which has been split-off from a larger, parent organization. Following a merger or simply complementing a strategic realignment on core areas, spin-outs provide an option to leverage assets of low strategic importance, or underexploited assets in their parent companies. The spin-out company takes personnel, assets, IP, technology, and existing products from the parent organization. In many cases the management team of the new company originates from the same parent organization. A corporate spin-out may initially face fewer difficulties than an academic spin-off, because companies, as par-

ent organisations, could assist a start-up company better than universities and research institutions (Jagersma and van Gorp 2003). The parent company provides the necessary assets and IP and an external investor finances the liquidity of the new start-up.

In the case of redundant capacities or non-core activities (e.g. after a merger of two companies), a spin-out can be used to reduce capacities and costs as an alternative to closing or selling the unit (Parhankangas and Arenius 2003; Bergh and Lim 2008). The reduction of capital requirements and risk, if R&D projects are not in the strategic focus of a company, can be another reason (Chemmanur and Yan 2004). As many areas of the R&D process chain can be outsourced and covered by external service providers, they will play a more important role in industrial R&D. Service oriented spin-offs and spin-outs contribute towards this, as these provide highly specialized services. Therefore, spin-outs can also be used as a method to make R&D more flexible for increased effectiveness and efficiency (Krishnaswami and Subramaniam 1999).

3 Methodology

3.1 Research approach and quality

The research method used in this study was the case study approach, due to its many benefits. It represents a combination of learning just by watching (Helper 2000) with the main advantage being that the object of study is studied in real life context (Yin 1981). Flyvberg (2006) states that "the case study produces the type of context dependent knowledge that research on learning shows to be necessary to allow people to develop from rule-based beginners to virtuoso-experts".

In contrast to the single case study approach, which aims at falsifying theoretical insights or to provide new insights in unexplored phenomena (Yin 2003; Yin 2006), many authors consider results from multiple case studies as more convincing, trustworthy, and robust (Eisenhardt 1989; Yin 2006). Therefore, the multiple case study approach was applied in this research, which compares cases and highlights resulting insights through similarities and dissimilarities between them. The cases were selected on an objective of maximum variation, thus enabling us to obtain information on the significance of various circumstances for the identified case studies (Flyvbjerg 2006).

In order to gain a better understanding of actual events and to avoid the influence of personal views and theoretical perspectives on the data collection, interviews based on a narrative approach (Polkinghorne 1988; Czarniawska 1998; Pentland 1999) were conducted, whereby the interviewees described their role with little interruption from the interviewer. To develop the case studies, semi-structured interviews were used as well as the inclusion of various sources of qualitative and quantitative data, such as document and literature analysis and observations (Yin 2006). As suggested by Eisenhart (1989), data triangulation was used to help achieve a more holistic view of the case studies. With the different rounds of interviews and the combination of the various sources of information collected over a long period of time, an in-depth description of the different technology transfer approaches was obtained.

Quality assurance is important when conducting explorative research applying a multiple case study approach and analysing qualitative data research (Bortz and Döring 2005; Yin 2006; Corbin and Strauss 2008; Lamnek 2008). As Yin (2006) stated, reliability of qualitative research can only be achieved by a structured way of proceeding and by exactly documenting the research process and its results. Since there can be no validity without reliability, a demonstration of validity is sufficient to establish reliability, so that reliability is a consequence of the validity in a study (Patton 2002).

3.2 Data collection and analysis

Between 2004 and 2006, literature research on academic spin-offs, corporate spin-outs and their application for technology transfer in both academic and practitioner oriented journals as well as the internet was carried out. With the information collected, a database was obtained with interesting examples from two industries (chemicals and pharmaceuticals) and two technologies (biotechnology and nanotechnology) in Germany and Switzerland. From this database, 15 academic spin-offs, 12 corporate spin-outs, 16 universities and research institutions as well as 6 TTOs, 25 companies and 23 venture capitalists (VCs) including corporate VCs were selected based on their fit to the research scope and their interest in and availability for an interview. Narrative interviews were conducted with them between 2006 and 2008. One-on-one interviews of approximately one hour were conducted in an unstructured, open-end way without any formal questionnaire. Prior to the interview, the interviewer collected in-depth information on the company or institution through various public sources (e.g. databases, website, press releases) to enable an efficient conduct of the interviews.

The selection of case studies from the interviews for the research was based on an objective of maximum variation to cover the whole range of

cases, the potential to obtain appropriate answers, and the willingness to further participate in this study. Table 1 shows details of the 12 selected case studies from Germany and Switzerland: 5 case studies each for academic spin-offs and corporate spin-outs and 2 for internal start-ups (see appendix). The same interviewer conducted again one-on-one interviews with the 12 selected case studies between 2008 and 2009. This time semi-structured interviews were used in order to develop these 12 case studies, whereby a reference set of questions was developed as a guideline for the interview, which allowed room for spontaneous answers. The questions were structured around different topical groups, like basic data regarding the case studies (parent institution and technology owner, involved parties), background for creating a new venture (reasons and strategy, relevance of technology transfer aspects), realization of the a new venture (conceptual design, engagement of investors, spin-off/spin-out process) and the results of these activities (development of the new venture, achievement of technology transfer goals).

The results of these semi-structured interviews as well as the narrative interviews were analysed and compared regarding the research questions. Additional secondary data was collected from the interviewees and through internet research for all the case studies. To identify relevant scientific literature and to update the case studies, a final literature research was conducted in the first half of 2011.

4 Results and discussions

4.1 Maturity of the technology

Within all analysed academic spin-offs the maturity of the technology was not sufficient to directly commercialize the technology. Table 2a shows the case specific mix of the identified aspects causing the need for further development of the technology and Table 2b case study specific details (see appendix).

All case studies had proof-of-concept only at laboratory scale with missing upscaling know-how to realize technical scale. Other aspects are no cost effective production processes, so that the new products cannot be produced on a cost competitive level, low relevance for industrial applications or insufficient performance. If there is no customer feedback, due to a missing prototype or access to customers, the customer acceptance of the new products is unclear. Further R&D is also necessary, if the new products have no competitive advantage in the eyes of the customers. No validation for commercial use and no fulfilled regulatory hurdles are also reasons for additional R&D activities. Case study B had a production technology for new nanomaterials only in laboratory scale without any expertise and experience for upscaling into the technical scale. The further R&D work focused on the upscaling of the laboratory process into a technical feasible process and development of formulations for a customer from the consumer industry. The result was a cost effective production process for a broad range of nanomaterials and formulations which could be directly used by the customer.

The identified kinds of further R&D work showed typical aspects. Equipment development means developing hardware and software for the cost efficient implementation of a new technology in the industry. Of importance is also upscaling of production processes through process development and the development of a cost effective production process. The improvement of performance enables the implementation in the industry. Scientific understanding of key aspects enables to improve the performance and to fulfil regulatory requirements. Other aspects are the development of industrial applications (e.g. implementation of products and technologies in the industry), the development of special grades or formulations for technical applications and the development of marketable products or service offerings. All these aspects were relevant for case study D. The development of industrial relevant strains for the proof of the genetic tools to modify microorganisms for the production of biofuels and bio-based chemicals was the critical step to get an industrial relevant strain with sufficient performance (yield, robustness) to produce ethanol in world scale production plants. Also within case study E, the improvement of biocatalysts in selected technical processes together with industrial partners was necessary to develop biocatalytic systems used in industrial applications with high performance and lower production costs compared to established chemical systems.

Typical results of the further R&D activities could be identified. An example for the importance of equipment for industrial applications and of providing of fee-for-service work is case study A. The high throughput experimentation technology had at the university only proof-of-concept in laboratory scale and high operational costs in industrial applications due to low automation of the process. The development of high throughput experimentation equipment enabled the spin-off to provide fee-for-service work for industrial customers and to sell the equipment to these customers. Other results were cost effective production processes for larger quantities, formulations for customer specific solutions and validated systems with cer-

tification.

The aspects describing the need for further R&D work in the case of corporate spin-outs and internal start-ups were rather similar to academic spin-offs, i.e. there is no clear difference between the three groups. Also, the kinds and the results of further R&D work were very similar in the three groups of case studies. Case study H shows that the corporate spin-out enabled the further development of selected technologies and correlated services based on scientific expertise. The result was a worldwide well-known provider of special pharma development services with strong teams consisting of scientists and marketing and sales experts. The described aspects were also relevant for case study K. The new nanomaterials from the laboratory were not really relevant for the industry as the particle size and the application properties were not suitable for industrial processes. Further R&D work of the internal start-up together with the business units of the parent company solved these problems. Another result was the cost effective production process for a broad range of nanomaterials and formulations which could be directly used by the consumer company in their products.

4.2 Acquisition of additional resources

Clear differences can be seen in the three groups, academic spin-offs, corporate spin-outs and internal start-ups, with regard to the acquisition of additional resources to realize the additional R&D work. Table 3a shows the identified aspects and table 3b the case study specific details (see Appendix).

Academic spin-offs need additional resources because there is no academic interest in further R&D, the topics are out of scope of universities or there are not enough resources at universities. Financing of additional resources is made by industrial partners, VC and corporate VC as well as strategic investors. Case study E showed the need for additional resources at universities in areas which are out of scope and not interesting from an academic point of view. The cost intensive further R&D work to develop industrial relevant biocatalysts could not be financed by the universities as technology owner and was financed by VC. Case study D is an example for a technology development within the academic scope of the university but where the necessary resources were not available at the university and a strategic investor financed these resources. Case studies A, B and C were examples of an investment of industrial partners who worked along with their investment also operationally close with the academic spin-off. The main reasons for investment are large market potentials and the opportunity of a trade sale or initial public offering (IPO) attracting strategic and VC investors.

For more and more non-core R&D projects in industrial companies there are not enough company internal resources (capital, management capacity) available resulting in the divestment of these projects. The need for additional resources for corporate spin-outs is caused by this divestment process from the parent company. In the case of corporate spin-out J, the parent organization spun-out parts of the clinical research department as an alternative to closing down operations. Another possible reason to realize a spin-out is the isolation of high risk projects, in order to protect the parent company from these risks, like in the case of case study G. The divestment of a drug development project by the parent company was the result of company internal problems during the development process which increased the further development risk significantly. These spin-outs enable companies to concentrate on their core activities, without having to abandon new products coming from these projects. As in the case of academic spin-offs, the additional resources are financed by industrial partners, VC including corporate VC and strategic investors. Reasons for the investment are, besides the opportunity of a trade sale or IPO, the realization of value creation potentials and to provide flexible services for the parent company. Case study H was the divestment of a pharma service department after the merger of two pharma companies. The spin-out was realized by the corporate VC department of the parent company together with strategic investors with pharma experience. A major intension of the parent company was, despite the reduction in headcount, to further use parts of the services which were no longer available inhouse on a flexible basis. Case study J was the divestment of parts of the clinical research department of a pharma company after the merger with another pharma company. Aim was the creation of a leading clinical research organization to further use these services.

The situation of internal start-ups is rather different compared to academic spin-offs and corporate spin-outs. The need for additional resources is due to the fact that the R&D work is too risky and the market proof-of-concept is not yet shown. As there are not enough resources in the business unit, the financing gap is closed by corporate R&D budgets. Within the case studies K and L, the relevant business units within a chemical company were not willing to finance the R&D work due to low success probability. The additional investment by corporate R&D budgets was made because there was the possibility to bring innovative products with over average profitability onto the market to strengthen the existing business. Aim from a cor-

porate point of view was increased innovativeness and the realization of growth option which could not be realized with only the resources of the business unit.

4.3 Technology transfer results

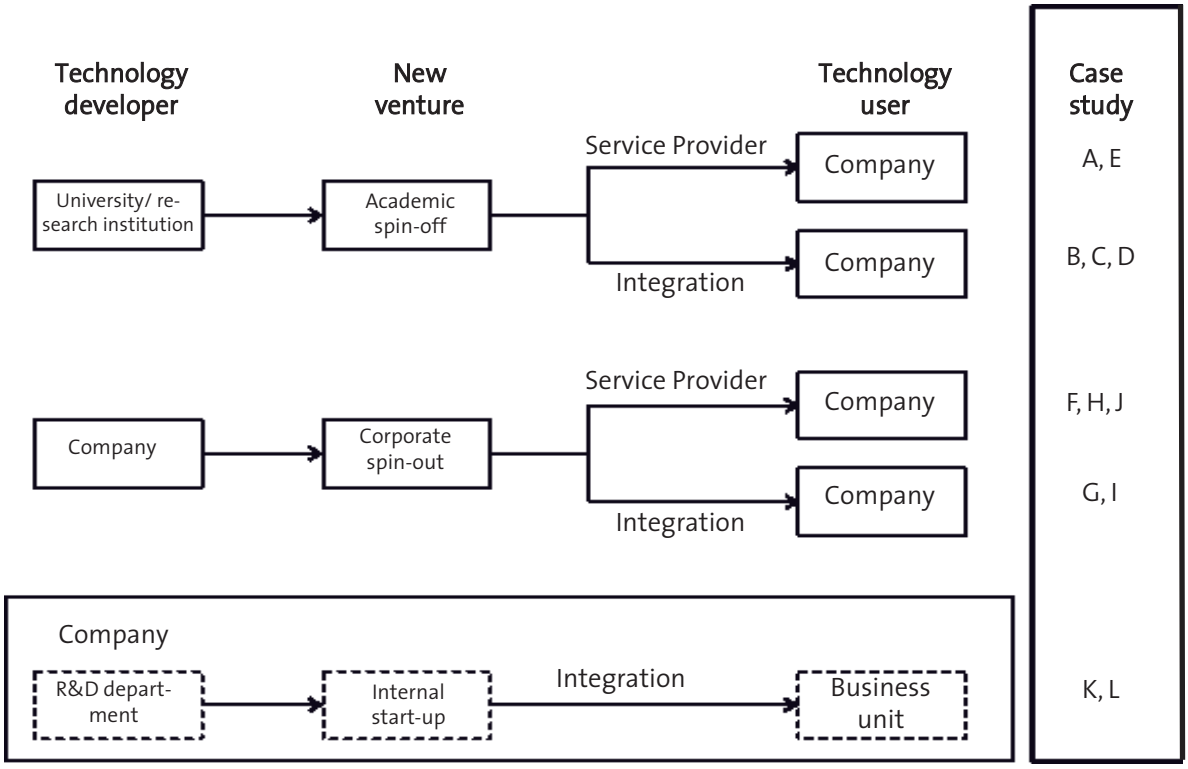
The analysis of the technology transfer results showed some similarities and dissimilarities between the three groups. Table 4a shows the analysis regarding technology transfer goal, technology transfer impact and technology transfer success and Table 4b some case study specific details (see Appendix).

In the case of academic spin-offs, the goal is the technology transfer from universities to industrial partners. In all analysed cases studies, the technology transfer was successful: there were some market introductions of new products and, in some cases, the integration of the spin-off into an industrial company. For example, in case study D, there was a joint development of a new product and the later acquisition of the academic spin-off by the industrial partner. This enabled the global market launch of a new product for ethanol by combining the production and marketing/sales capabilities of the buying company and the technologies of the acquired spin-off. This is an example of the transfer of a technology from a university to a company via the purchase of the spin-off company. Case study A shows that the technology transfer is not only done through the sale of the spin-off but also by acting as a service provider for industrial customers.

Corporate spin-outs realize technology transfer from the parent company as a new legal entity to further develop the technology as an alternative to closing the operations. As in the case of academic spin-offs, the technology transfer can be realized by the trade sale to a new owner or by acting as a service provider. The case studies showed in some cases the market introduction of new products and in other cases the integration into a new company. For example, case studies H and J executed the transfer of the operations into a new legal entity with the aim to further develop and commercialize the services offerings. The result was independent companies with cost competitive services which were widely used by the former parent companies as well as other customers from the pharmaceutical industry.

Internal start-ups, like case studies K and L, show

Figure 1 Technology transfer by academic spin-offs, corporate spin-outs and internal start-ups.



the technology transfer from R&D departments into a commercial business unit. Result was in both cases the integration of (parts of) the internal start-up into a business unit of the parent company in combination with the introduction of new products into the market.

5 Implications and conclusions

The analysis of the case studies confirmed that the creation of new ventures could be used for technology transfer from university, research institutions and companies as technology developers to companies as technology users (figure 1). In all case studies the maturity of the technology was not sufficient to directly commercialize the technology. Necessary was the further development of the technology to a stage interesting for established companies which are looking to offer concrete products or services. The technical proof-of-concept has normally to be done before investments in production, marketing and sales are made. The need for further R&D work is a central element of using new ventures for technology transfer combined with the fact that the parent organization (universities, research institutions and companies) is not able or willing to finance this additional R&D work.

Academic spin-offs can especially help to transfer technologies to the industry if they are out of scope of the academic institutions or there is no academic interest in the work. Corporate spin-outs can be used for technology transfer as a good alternative to closing R&D operations if they no longer fit into the parent organization and the technology is not mature enough to sell it directly. Both spin-offs and spin-outs have to acquire additional resources from external partners like financial investors or industrial co-operation partners to increase the maturity of the technology. The technology transfer back to industrial companies can work in two ways: the new ventures can work as service provider as an independent company or be sold and integrated into a new company.

The principle of company internal start-ups, which is using many elements of academic spin-offs and corporate spin-outs, can help to improve technology transfer from research labs of R&D departments to commercial business units within the same company. The internal start-up will be integrated into an operational business unit if the technological and market proof-of-concept is shown. Corporate spin-outs and internal start-ups can overcome innovation barriers like bureaucratic thinking, fear of cannibalism or the well-known 'not invented here' syndrome which are normally found within companies.

The new ventures enable the opportunity to combine scientific expertise with business expertise of external managers or entrepreneurs. They can more easily pick up external impulses and serve as a mechanism to explore revolutionary ideas in a setting apart from mainstream business. For example, competencies from other companies or top-class scientists from universities and research institutions can be engaged to form excellent teams.

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Appendix (see the following tables)

Table 1 Characterization of the case studies.

Type	Case Study	Parent institution and starting point	Year and reason for founding a new venture	Import realization steps and current status
Academic spin-offs	A	University in Germany: High throughput experimentation technology with proof-of-concept in the laboratory and potential for chemical companies	1999 / Additional financial resources for the development of the technology to a stage interesting for established companies	VC financing (including corporate VC of a chemical company) with industry co-operations from the beginning / Chemical company as majority shareholder
	B	University in Germany: Production technology in laboratory scale for new nanomaterials with potential applications in consumer products	2000 / Additional financial and human resources for the development and testing of products for the consumer market	Spin-off supported by a consumer company providing money and management capacity / Integration into consumer company
	C	University in Germany: Specialized and non validated laboratory testing system to develop and study new active ingredients for cosmetics without animal tests	2001 / Additional financial and human resources to use the system in a broad set of validated applications in the cosmetics industry	Finding an industry partner from the cosmetics industry to support the spin-off process / Integration into cosmetics company
	D	University in Germany: Genetic tools to modify microorganisms for the production of biofuels and first laboratory strains for ethanol production	2007 / Acquisition of strategic investors for further funding of the technology development (e.g. the development of industrial relevant strains)	R&D work at the university financed by the investor and co-development of a first product together with an industry partner / Trade sale to industrial partner
	E	University in Germany: Molecular biological tools to modify microorganisms in the laboratory to develop cost effective biocatalysts for new applications	2008 / Further development of the biocatalysis technology from laboratory scale to technical scale in a broad range of applications	VC financed development with industrial partners to show the technical proof-of-concept / Independent company
Corporate spin-outs	F	Pharma company in Switzerland: Trade sale of a pharma company's liquid crystal business, without the R&D department, to another company	1995 / Spin-off of the R&D department to bring in VC investors for further funding of the technology development	Development of the R&D department into a fully integrated company from raw material sourcing to marketing and sales / Independent company
	G	Pharma company in Switzerland: Desinvestment of a drug development project with a failed drug candidate of a pharma company	1998 / Possibility for further funding of the drug development and to acquire other drug candidates (especially a cost competitive production route)	Building-up an own pipeline of drug candidates through in-licensing and development of own projects / Integration into former parent company
	H	Pharma company in Switzerland: Reduction of overcapacities of a broad range of pharma development services after the merger of two pharma companies	1999 / Possibility to deliver the partly, very specialized services with high hardware costs to a broader group of customers from the pharma industry	Restructuring of the operations to provide a cost competitive range of services needed by the pharma industry / Independent company
	I	Strategic decision of a chemical company to divest parts of the non-core pharma operations	2001 / Acquisition of VC investors for further funding of the technology development	Restructuring of the operations including sale of parts to other companies and development of a pipeline of drug candidates / Merger with another company
	J	Pharma company in Germany: Reduction of the overcapacities within the clinical research operations after the merger of two pharma companies	2002 / Possibility to deliver the partly, very specialized clinical research services to a broader group of pharma companies	Focusing of the service offerings to target special niche markets and restructuring of the company's internal resources / Independent company
Internal start-ups	K	Chemical company in Germany: Laboratory scale production technology for nanomaterials for a broad range of applications	2003 / Company internal cannabilization effects with established products	Building-up of an own semi technical production facility to deliver larger quantities of the nanomaterials to customers / Integration into business unit
	L	Chemical company in Germany: Technology to produce very specific catalysts for organic chemical synthesis	2004 / Low acceptance of the new catalytic approach within the established R&D organization of the chemical company	Developing of a broad range of catalysts and building-up of a marketing and sales team / Integration into business unit

Table 2a Maturity of the technology (overview).

	Case study												
	Academic spin-offs					Corporate spin-outs					Internal start-ups		
	A	B	C	D	E	F	G	H	I	J	K	L	
Need for further development													
Only proof-of-concept at laboratory scale	X	X	X	X	X	X	X	X	X	X	X	X	
No upscaling into technical scale	X	X	X	X	X	X	X	X	X	X	X	X	
No cost effective production process	X	X		X	X	X	X	X	X	X	X	X	
Low relevance for industrial applications	X	X	X	X	X	X		X		X	X	X	
Not sufficient performance	X	X	X	X	X	X		X		X	X	X	
No customer feedback	X	X	X	X	X	X			X		X	X	
No competitive advantage		X	X	X	X	X		X	X	X	X	X	
No validation for commercial use	X	X	X	X	X	X	X	X	X	X	X	X	
Not fulfilled regulatory hurdles			X				X		X	X			
Kind of further development													
Equipment development	X			X		X		X			X	X	
Process development/upscaling	X	X		X	X	X	X	X	X	X	X	X	
Development of a cost effective production process	X	X		X	X	X	X	X	X	X	X	X	
Scientific understanding of key aspects	X	X	X	X	X	X	X	X	X	X	X	X	
Improvement of performance	X	X	X	X	X	X	X	X	X	X	X	X	
Development of marketable products/services	X	X	X	X	X	X	X	X	X	X	X	X	
Usage in industrial applications	X	X	X	X	X	X	X	X	X	X	X	X	
Result of further development													
Equipment for industrial applications	X			X		X		X			X	X	
Providing of fee-for-service work	X		X	X	X	X		X		X	X	X	
Cost effective production process for larger quantities	X	X		X	X	X	X	X	X	X	X	X	
Performance high enough for industry	X	X	X	X	X	X	X	X	X	X	X	X	
Customer specific products/services	X	X	X	X	X	X	X	X	X	X	X	X	
Validated systems with certification	X		X				X	X	X	X		X	

Table 2b Maturity of the technology (case study specific details).

Type	Case Study	Why was the need for further development of the technology?	What kind of further development of the technology was necessary?	What was the result of the further development work?
Academic spin-offs	A	High throughput experimentation technology only with proof-of-concept in the laboratory scale at the university and high operational costs due to low automatization	Automatization of the high throughput approach including the development of the necessary equipment to fulfil the requirements of industrial customers	High throughput experimentation equipment which was used for fee-for-service work for customers and sale of the equipment to these customers
	B	Production technology for new nanomaterials only in laboratory scale without any expertise and experience for upscaling into the technical scale	Upscaling of the laboratory process into a technical feasible process and development of formulations for a customer from the consumer industry	Cost effective production process for a broad range of nanomaterials and formulations which could be directly used by the consumer company in their products
	C	Specialized laboratory testing system without any validation to use it for regulatory purposes in the cosmetics industry	Scientific understanding of the test systems for validation purpose and for usage in a broader scope of potential applications	Validated test system accepted by the regulatory authorities in the cosmetics industry which could be used in skin care projects as test system
	D	Only first laboratory strains for ethanol production with low relevance for industrial application and no robust industrial strains	Development of industrial relevant strains for the proof of the genetic tools to modify microorganisms for the production of biofuels and biobased chemicals	Industrial relevant strain with sufficient performance (yield, robustness) to produce ethanol in world scale production plants
	E	First reactions with new biocatalysts in the laboratory with insufficient activity of the catalysts	Improvement of biocatalyst activities in selected reactions and usage in technical processes together with industrial partners	Different biocatalytic systems used in industrial applications with high performance and lower production costs compared to established systems
Corporate spin-outs	F	Broad range of liquid crystal research projects with the need to focus and develop them to an industrial relevant stage	Introduction of a market oriented project management system, selection and development of the most promising projects towards marketable products	Broad range of products for the security market based on liquid crystals and promising R&D project pipeline
	G	Drug candidate in clinical phase I and other clinical tests to obtain permission to enter the market and cost effective production process	Clinical studies in phase II and III, submission of all necessary data to the regulatory authorities and development of a cost effective production process	Successful pass of the clinical phase III and implementation of a cost effective production process
	H	Broad range of pharma development services without competitive advantage compared to other service providers	Further development of selected technologies and correlated services based on scientific expertise to be global market leader in these service segments	Provider of special pharma development services with strong teams consisting of scientists and marketing and sales experts
	I	Development of drug candidates to bring own products to the market	Further development of the early stage drug candidates to marketable products	Drug candidates in later stages and also products on the market
	J	Very specilized clinical research services without the ability to handle the generated data in the drug development process	Development of the services towards complete service offerings based on high scientific standards including data handling	Cost effective provider of special pharma development services with strong data handling ability
Internal start-ups	K	Only laboratory scale and not application specific production technology for nanomaterials	Development of applications for the nanomaterials together with a cost effective technical scale production process	Broad range of nanomaterials provided to different company internal and external customers
	L	Only laboratory scale production technology for specific catalysts for organic chemical synthesis	Development of a broad range of synthesis routes for the catalysts together with customers	Broad range of catalysts mainly to company external customers in the chemicals and pharma industry

Table 3a Acquisition of additional resources (overview).

	Case study											
	Academic spin-offs					Corporate spin-outs					Internal start-ups	
	A	B	C	D	E	F	G	H	I	J	K	L
Need for additional resources												
No academic interest	X	X	X		X							
Out of scope for universities	X	X	X		X							
Not enough resources at universities	X	X	x	X	X							
Divestment of non-core operations						X	X	X	X	X		
Spin-out as alternative to closing operations						X	X	X	X	X	X	X
Not enough resources in the business units											X	X
Development work too risky						X	X	X	X	X	X	X
Market proof-of-concept not yet shown						X	X		X		X	X
Financing of additional resources												
Industrial partners	X	X	X						X		X	X
VC (including corporate VC)	X				X		X	X		X		
Strategic investors				X		X						
Corporate R&D department											X	X
Reason for investment												
Large market potentials	X	X		X	X	X	X		X	X	X	X
Opportunity of a trade sale or IPO	X			X	X	X	X			X		
Realization of value creation potentials								X		X		
Flexible services for the parent company								X		X		
Increased innovativeness of the parent company								X			X	X
Realization of growth option for the parent company											X	X

Table 3b Acquisition if additional resources (case study specific details).

Type	Case Study	Why were additional resources necessary?	Who financed the additional resources?	Why was this investment made?
Academic spin-offs	A	Equipment development at the university not possible (out of scope and no resources available)	R&D contracts with industrial partner interested in the technology and later VC (including corporate VC of the industrial partner)	Interest of the industrial partner in this technology and especially the equipment to implement the technology inhouse
	B	Cost intensive upscaling of the nanomaterials production process out of scope at the university	Money and management capacity from a consumer products company, as preferred commercial partner, based on an exclusive agreement	Nanomaterials for the improvement of existing products as one of the strategic growth projects within the consumer products company
	C	No academic interest in developing and validating the test system	Money and management capacity from a cosmetics company, as preferred R&D and commercial partner	Test system as an important step towards developing cosmetics without animal tests due to the public's critical view regarding animal tests
	D	Development of an industrial strain within the academic scope but necessary resources (scientists and equipment) not available at the university	Strategic investment of a company from the renewable energy sector to further develop the technology at the university on the basis of research contracts	Large market potential and possible synergy effects to the core business of the strategic investor
	E	No academic interest in developing industrial relevant biocatalysts due to restricted resources at the university	Investment from two VCs for the build-up of own laboratories for the development and commercialization of new biocatalysts	Market potential of the biocatalysts within the area of industrially relevant catalyst development
Corporate spin-outs	F	Divestment of the R&D department by the parent company due to focusing on the core business	Strategic investor with majority stake of the spin-out company based on a long term strategic engagement in this area	Trade sale to an established company or an IPO after successfully building up the business
	G	Divestment of the drug development project by the pharma company due to problems during the development process	Strategic investors with own entrepreneurial experience in the pharma industry and two VC companies with pharma focus	Market potential of the drug candidate and attractiveness of the business model to develop drugs within a virtual pharma company with external resources
	H	Divestment of the pharma service department by the parent company after the merger of two pharma companies	Corporate VC department of the parent company together with strategic investors with pharma experience	Intension of the parent company to further use parts of the services on a flexible basis (despite reducing the head count)
	I	Divestment of parts of the pharma operations of the parent company due to strategic reasons	Biopharmaceutical company in North America as long-term strategic investor	Strategy of the parent company to find a new owner for a fully integrated pharma company to earn as much money as possible with the trade sale
	J	Divestment of parts of the clinical research department by the parent company after the merger with another pharma company	Parent company has long-term strategic investor together with a VC company	Aim to create a leading clinical research organization as alternative to closing the operations due to high costs and negative image aspects
Internal start-ups	K L	Relevant business units within the chemical company not willing to finance the development work due to low success probability	Corporate R&D budget within the parent company managed by the corporate R&D department	Possibility to bring innovative products with over average profitability onto the market to strengthen the existing business

Table 4a Technology transfer results (overview).

Type	Technology transfer goal	Technology transfer impact	Technology transfer success
Academic spin-offs	Technology transfer from the university and further development to use it by industrial partners	Transfer from the university to an industrial company via a spin-off (trade sale or service provider)	Yes, because market introduction of new products and in some cases integration into an industrial company
Corporate spin-outs	Technology transfer into a new legal entity to further develop the technology as alternative to closing the operations	Transfer from the parent company to the new owners via a spin-out (trade sale or service provider)	Yes, because market introduction of new products and in some cases integration into an industrial company (as well as survival of divested entities)
Internal start-ups	Technology transfer from R&D department into a commercial business unit	Integration of (parts of) the internal start-up into a business unit of the parent company	Yes, because market introduction of new products

Table 4b Technology transfer results (case study specific details).

Type	Case Study	What was the technology transfer goal?	What was the technology transfer impact?	Was the technology transfer approach successful?
Academic spin-offs	A	Transfer of the technology from the university and further development for application by industrial companies to improve materials R&D	Chemical company as majority shareholder for preferred access to the technology	Yes, because the technology is intensively used by chemical and material companies
	B	Transfer of the technology from the university to the industrial partner to develop new nanotechnology based products	Complete integration into the consumer company after successful market introduction of the first products	Yes, because the industrial partner integrated the spin-off after developing the technology to a maturity stage which could be used by the industrial partner
	C	Transfer of the technology from the university to the industrial partner to improve and validate the testing system	Integration into the R&D department of a cosmetics company to broadly use the testing system for new product developments	Yes, because the industrial partner integrated the spin-off after developing the technology for industrial application on a broader basis
	D	Transfer of the technology from the university to the industrial partner via purchase of the spin-off company	Trade sale to the industry partner to globally launch the product for ethanol production on to the market and to develop other products	Yes, because the technology was the missing link for an industrial company to bring a new product to the market
	E	Transfer of the technology from the university to the industrial partners on the basis of co-operations	Co-operations with chemical and pharmaceutical companies to show first technical scale applications of biocatalysts	Yes, because different industrial co-operation partners use the technology in their production processes
Corporate spin-outs	F	Transfer of the liquid crystal technology into a new legal entity to further develop the technology	Independent company as technology leader in its market segments with a broad product range already introduced into the market	Yes, because a broad range of products based on the technology has been introduced into the market
	G	Transfer of the drug development project into a new legal entity to proceed the development programme	Reintegration into the former parent company after successful development of the drug candidate with external service providers	Yes, because the drug will be introduced into the market by the former and new parent company
	H	Transfer of the operations into a new legal entity to complement and further develop the services	Independent company with cost competitive service range especially for the former parent company	Yes, because the services are widely used by the former parent company as well as other customers from the pharmaceutical industry
	I	Transfer of the drug candidates and other operations into a new legal entity to further develop the drug candidates and to restructure the operations	Merger with a publicly listed biopharmaceutical company in North America	Yes, because the drug candidate projects have been further developed and one product has already been introduced into the market
	J	Transfer of the services into a new legal entity to strengthen the service offerings	Independent company with integrated services for the pharma industry	Yes, because the services are widely used by different customers from the pharmaceutical industry
Internal start-ups	K	Transfer of the technology from R&D department into a commercial business unit	Integration of the internal start-up into a business unit of the chemical company	Yes, because the chemical companies commercialized the technology by introducing new products into the market
	L			

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Practitioner's Section

LEAN SCM: A paradigm shift in supply chain management

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Supply chain management (SCM) requirements have changed significantly in recent years. The buzzword nowadays when managing global supply chains is adaptation to increasing global complexity and volatility. Growing pressure from financial markets and the difficulty of increasing operating margins and working capital in this environment require efficient planning and execution of global production processes. More and more companies are relying therefore on LEAN SCM - a planning concept for harmonized production and replenishment planning across the entire supply chain with close linkages to organizational processes and IT infrastructure. It is designed expressly to simplify existing planning processes and to improve the synchronization and variability management of global supply chains. This article provides an overview of the key elements of LEAN SCM and its applications in process industries.

1 Introduction

A recent survey of supply chain managers impressively demonstrates the urgent need to adapt existing SCM concepts to the new reality: Three-quarters of top managers consider market volatility to be the biggest challenge to their supply chains, followed by supply chain complexity (Cecere, 2013). Most companies have chosen adapting their business processes to the "VUCA" world - an acronym of the words "Volatility", "Uncertainty", "Complexity" and "Ambiguity" - as a major strategic target. In this context, global SCM can play a key role in a company's success.

Particularly for companies in process industries, increasingly frequent, ever-widening market fluctuations, associated with the high level of complexity involved in globally dispersed production processes confronts them with hitherto unknown problems and challenges. Production processes in the chemical industry, for example, are generally characterized by long production times. Production of chemical materials - the basis of numerous industries from tablet computers to cars to cosmetics - often takes months. If the chemical supply chain cannot respond quickly to fluctuations, supply bottlenecks will very quickly threaten many downstream industries. Particularly in the pharmaceutical industry, to take another example, the reliability of supply is the highest principle: It is simply unacceptable to allow poor supply chain planning to threaten the supply of essential drugs.

To ensure optimal responsiveness and efficiency in supply chain processes, almost all companies in process industries have in recent decades established global planning departments and invested heavily in their planning systems. The challenges of today's VUCA world show more and more the major flaw of Advanced Planning and Scheduling (APS) and Enterprise Resource Planning (ERP) systems that form the planning backbone of the global value chain: They work effectively only when extremely reliable forecasts, especially regarding market trends and customer demand, are available.

In this article, we introduce LEAN SCM as a concept that enables firms in process industries to overcome the flaws of traditional ERP and APS planning approaches. Due to the extensive interdependency of SCM and supply chain planning, we use 'LEAN SCM' and 'LEAN Supply Chain Planning' interchangeably.

2 The role of APS and ERP systems

Over the course of their evolution, supply chain planning systems have always responded to emerging challenges. Since the advent of computers and the Internet, the implementation of new business concepts for planning has been intertwined with the use of information technology (IT); in some cases, it was the availability of new technologies that led to major breakthroughs in planning and SCM. Three concepts - material requirement planning (MRP), ERP, and APS - resulted in major changes in planning approaches. Following Packowski (2013), we briefly outline how these three approaches operate and explain why they struggle to deliver acceptable results when operating in a VUCA world.

In many companies, supply chain planning typically centers on the concept of MRP, which became popular in the 1960s as a solution for addressing a growing number of products and production steps. Based on demand for finished goods, MRP supports the calculation of required production volumes and precursor materials. As it grew in popularity, MRP also grew in scope, and evolved in the 1980s into manufacturing resource planning (MRP II), which combined MRP with master scheduling, rough-cut capacity planning, capacity requirements planning (CRP), and other functions. With the development of client/server IT architecture, it became feasible to integrate virtually all of a corporation's business applications with a common database. This technological advancement led to the development of ERP, offering integration of internal and external information across an entire organization, and integrating all MRP/MRP II functionalities on one common platform; today, ERP systems form, at least in order execution, the backbone of virtually all supply chain planning organizations.

At the end of the 1990s, in the face of globalized manufacturing and delivery processes, SCM as a corporate function rose to prominence. In parallel with the growing number of SCM departments and functions across companies, APS technology became an important cornerstone of most supply chain initiatives. The combination of SCM business concepts and APS as a technology platform provided companies with the means to implement globally integrated planning processes, encompassing multiple sites and countries. Modern APS solutions essentially adhere to the same principles as MRP II but are designed to cope with complex supply networks across plants and regions. They are capable of integrating all material flows of intermediates between production plants. In contrast to locally and site-oriented planning in ERP systems, APS provides additional functionalities for global visibility and planning. Equipped with modern in-memory database technology and enabling advanced mathematical optimization methods, APS promised to solve complex planning problems in global value chains.

Although APS and its predecessors such as MRP and ERP delivered substantial benefits to many companies, they all have an Achilles heel: depending heavily on accurate input for planning in the form of demand forecasts. If the input does not have the required quality, planning faces multiple issues regarding costs and service. And as the painful experiences of many companies show, forecast accuracy is often not sufficient, resulting in poor planning results as well as complex counter-measures in daily operations. A supply chain manager at one of the world's largest pharmaceutical manufacturers commented: "Can you tell exactly at which wedding or family reunion you will be in twelve months? Certainly not! But our planning systems, however, expect to be able to set production and scheduling decisions twelve months ahead." (Bohl, 2010).

3 LEAN SCM: Definition and key elements

3.1 Definition

LEAN SCM is designed to enable production and replenishment planning across the entire supply chain in a synchronized way. LEAN SCM is influenced by two main developments: first, traditional supply chain planning and, second, the rise of lean operations.

On the one hand, LEAN SCM aims to overcome the well-known drawbacks of (traditional) ERP, MRP, or APS - dependency on forecasts and their inherent complexity. On the other hand, it also aims to translate lean manufacturing principles such as production leveling, takts, and pull production into supply chain planning in order to allow for more simplified and consumption-driven processes. For a more detailed discussion of lean manufacturing, we refer the reader to Wormack et al. (2003, 2005). Today, however, these popular lean approaches are predominantly used at the shop-floor level in plants, but are less frequently employed in supply chain planning. Here it is important to emphasize that LEAN SCM is designed as a holistic business concept, also incorporating guidelines for alignment with organizational processes and integration into IT infrastructure (Packowski 2013).

3.2 Key elements

Three planning and management concepts are particularly emphasized in order to effectively align planning processes in process industries with the

requirements of the VUCA world. They also form the key elements of LEAN SCM (Packowski, 2013; http://www.leansupplychainplanning.com).

Cyclic Planning with Rhythm Wheels

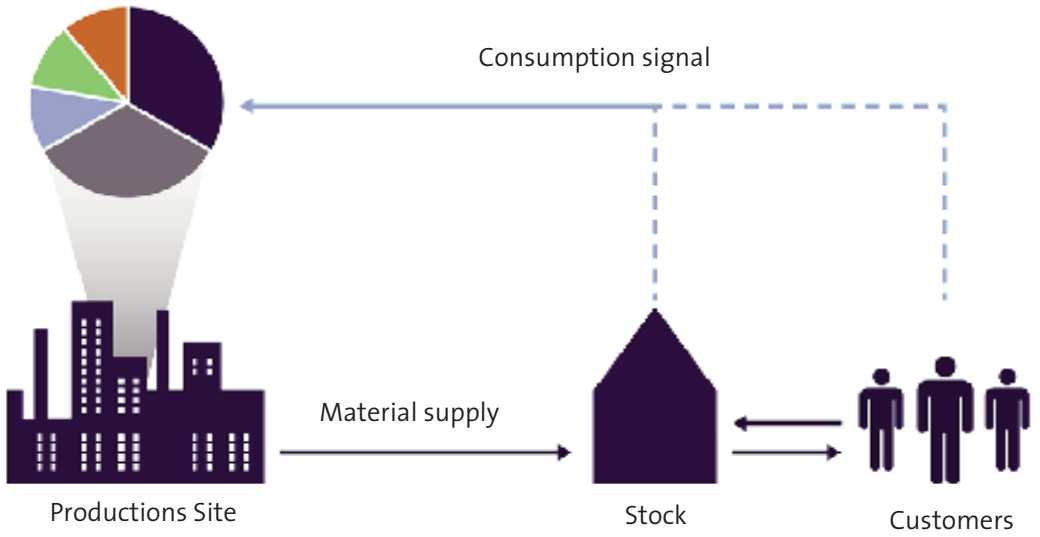
Many companies have achieved great success incorporating lean manufacturing principles when designing their manufacturing operations to achieve greater efficiency. With cyclic planning and control of entire supply chains is it now possible to transfer these ideas to global end-to-end production processes. In process industries it is especially important to devote attention to the optimal design of set-up procedures and campaign sizes, as well as to orient them in accordance with rapidly changing market demand. Without optimal set-up sequences - for example shifting from bright to dark colors or from high to low concentrations - companies risk substantial production losses and cost increases.

To reduce inventory and increase the utilization of capital-intensive equipment, more and more companies rely on "Rhythm Wheels." During the past decade, these planning approaches rose to popularity in process industries as a promising alternative to MRP and its variants (e.g. Foster, 2007; King, 2009; Packowski et al., 2010). These planning models make it possible to efficiently plan a variety of products at a plant or production asset while at the same time smoothing capacity load to avoid costly production peaks. The concept of Rhythm Wheels is rooted in the classical economic lot scheduling problem (ELSP), which aims to design a cyclic production schedule that minimizes production and inventory costs (Elmaghraby, 1978). Besides reducing dependency on accurate forecasts, it is also recognized as a highly intuitive planning tool for operations managers.

Figure 1 illustrates the nature of Rhythm Wheels: A Rhythm Wheel continuously repeats a given production sequence. Each spoke of the wheel symbolizes the production of a certain product. The Rhythm Wheel arranges the products in an optimal order to utilize assets and operations more cost effectively. When planned according to Rhythm Wheels, production processes can even be perfectly aligned with fluctuating market demand. The lengths of the wheel's spokes - and thus production volumes - are continuously synchronized based on a pull-logic according to existing stocks and customer orders.

To implement Rhythm Wheels for a broader range of products, certain modifications to standard approaches in the literature (e.g. King, 2009) are required: first, rules for dynamic cycle times (the time for one turn of the wheel) and second, rules for manufacturing certain products not in every cycle but, for example, in every third or fourth cycle. As part of the LEAN SCM concept, Packowski (2013) introduces novel variants of the Rhythm Wheel - Breathing and High-Mix Rhythm Wheels - to incorporate such rules.

Figure 1 Real consumption should trigger pull-production.



End-to-end synchronization along the supply chain

Value chains in process industries are typically extended across a variety of production stages and are often spread over several plants around the world. In order to ensure cost effectiveness and alignment with markets, supply chain synchronization is of utmost importance. Only effective synchronization can relegate production delays or even failures to the past. In this context Rhythm Wheels can achieve significant improvement; they not only optimize processes in order to determine the load on a production machine, they also help to achieve effective global timing mechanisms for production processes along all parts of an international supply chain.

Two dimensions are of utmost importance for end-to-end synchronization: first, the alignment of cycle times across different Rhythm Wheels in order to avoid starvation or idle times; second, the alignment of production and inventory planning along the supply chain. As indicated in figure 2, all steps along the supply chain should be closely coordinated with one another - and, ideally, mesh like gears. In the context of Rhythm Wheels, such synchronization is achieved by establishing a global takt in the supply chain that makes it possible to align the cycle times of the various Rhythm Wheels across the supply chain. Furthermore, to achieve stable synchronization inventory buffers need to be aligned with the cycle times in production (we refer the reader to Packowski (2013) for a detailed discussion of synchronization approaches).

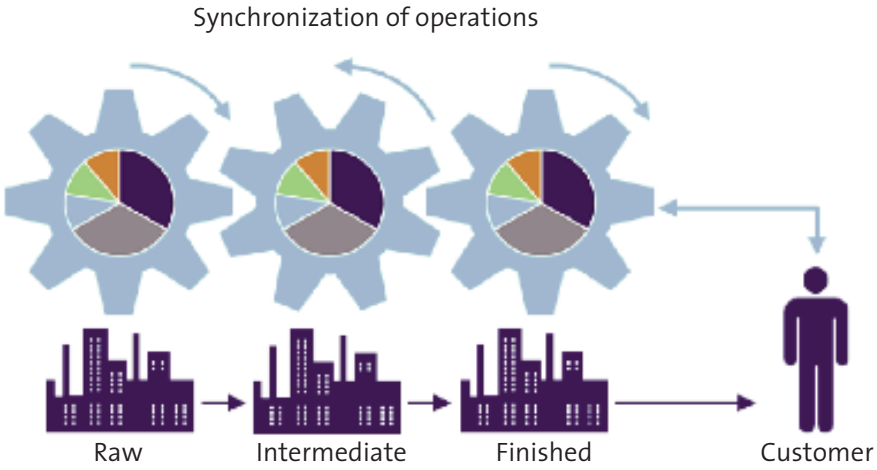
Traditional planning concepts, however, have always failed in this respect. Unless production orders are adapted to local conditions, effective synchronization of upstream and downstream production stages is nearly impossible. By establishing a stable production takt with Rhythm Wheels, complex production networks in the chemical and pharmaceutical industries can be successfully synchronized, thereby reducing lead times and increasing responsiveness.

Variability management on the capacity and inventory side

In many companies in process industries, it has been common practice to counteract demand fluctuation primarily through adjustments of production plans. However, (safety) stocks - although the name suggests they are meant to absorb the impact of market volatility - were previously thought of only for planning a red line such that tapping into such (safety) stocks would spread panic through planning departments. The consequences of such one-sided variability management, however, are no longer acceptable in the VUCA world. While stocks and thus capital costs continue to rise, production peaks can be met only by maintaining costly excess capacity and incurring overtime costs in the workforce.

LEAN Supply Chain Planning helps companies manage variability efficiently. By adjusting cycle times in production, capacity can be utilized consistently to actively counteract production peaks -

Figure 2 Operations are synchronized by the synchronization of supply chain parameters.



in capital-intensive companies in process industries this is a key competitive advantage. If actual demand is significantly above expectations, stocks are actively used in planning. Indeed, it is among the great advantages of LEAN Supply Chain Planning that planning cyclically with Rhythm Wheels makes it possible to match production capacity with stocks more efficiently (see figure 3).

To bring production and replenishment planning together when dealing with volatile environments, the alignment of production planning parameters and inventory targets is elementary. LEAN SCM therefore propagates planning processes with which to determine cycle times, planned production quantities, and safety stock targets not in isolation but jointly to allow for cost efficiency while meeting service targets. For instance, when changing the allowable range for cycle time variations at a Rhythm Wheel-managed production asset, the safety stock targets must be adjusted as well. In any case however, it has to be ensured that safety stocks are actively used in the planning and execution process and do not remain a "dead" - no longer used - entity.

4 Results and industry trends

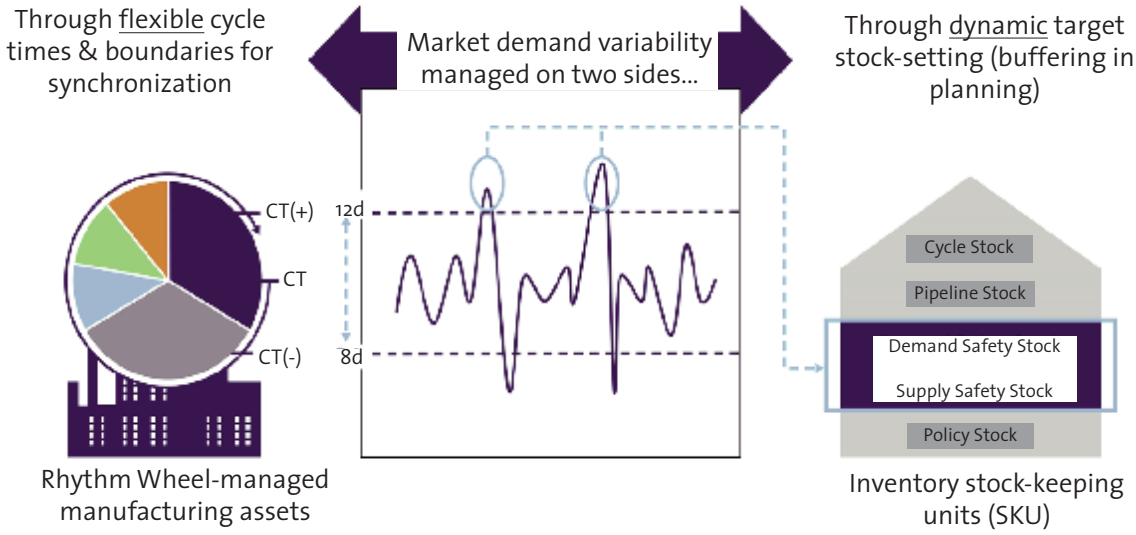
After introducing the key elements of LEAN SCM, we will summarize improvement results for selected supply chain metrics that have been achieved with the implementation of LEAN SCM. Furthermore, we will also provide an overview of LEAN SCM applications in process industries.

4.1 Results for selected supply chain metrics

Many companies have recognized that the more complex and challenging requirements of the business world demand new and innovative approaches in supply chain planning and coordination. Many consider targeting just individual elements in their planning processes, for example improving forecast accuracy or optimizing inventory, as a failed strategy. Such piecemeal efforts at most cure symptoms on a short-term basis, but they do not create the agility and robustness needed by modern supply chains in the VUCA world. More and more companies are therefore relying on LEAN Supply Chain Planning because it greatly simplifies existing planning processes and helps in particular to improve synchronization and variability management along global supply chains.

Companies that have implemented LEAN Supply Chain Planning report consistently positive experiences with the new approach. Through better variability management (addressing a major challenge of the VUCA world) it is possible to significantly improve the management of stocks, service levels, and lead times. The results shown in figure 4 are based on industry cases reported in Packowski (2013). Due to concerns with confidentiality the results from the various cases which involve leading companies such as BASF, Novartis, AstraZeneca and Eli Lilly were averaged. Overall, six

Figure 3 Market demand variability is managed on two sides



industry cases are reported in Packowski (2013), providing the basis for the results reported in figure 4.

4.2 Industry trends

Based on the experience of various consulting projects by Camelot Management Consultants in the field of LEAN Supply Chain Planning, we briefly discuss in this section the specific needs of companies in process industries. In particular, we identified various industry-specific success factors that facilitate the planning and successful implementation of LEAN in process industries:

- Chemicals: Such pioneers and industry leaders in the chemical industry as BASF, Dow Chemical, and DuPont all rely today on cyclic scheduling with fixed production sequences. A central motivation for introducing LEAN SCM for manufacturers of both specialty and basic chemicals, in addition to generally simpler planning processes, is above all more efficient synchronization of their often highly complex global production processes.

- Pharmaceuticals: Due to similar challenges related to production processes, global pharmaceutical manufacturers tried very early on to adopt cyclical planning with the help of Rhythm Wheels that had been used in the chemical industry. A key milestone for companies such as Novartis and AstraZeneca, however, was the development of so-called "High-Mix Rhythm Wheels," which enable cyclic planning in packaging plants that produce a variety of SKUs.

- Consumer goods: Continuous production processes and batch production are also essential features of the consumer goods industry, which is why, when facing the challenges of the VUCA world, the industry has been re-thinking global supply chain planning. Industry giants such as Procter & Gamble, Coca Cola, and Nestlé rely on LEAN SCM concepts to sustainably and efficiently align their supplies with their customers. Custom-tailored IT solutions are essential to ensure rapid response in the market.

In this article, we provided an overview of the concept of LEAN SCM as a response to the new supply chain planning challenges that arise in today's dynamic and volatile business environment. We highlighted cyclic planning, synchronization and variability management on the capacity and inventory side as key elements of LEAN SCM. Based on reported industry cases in Packowski (2013), we summarized what improvement potential can be unlocked by the implementation of LEAN SCM.

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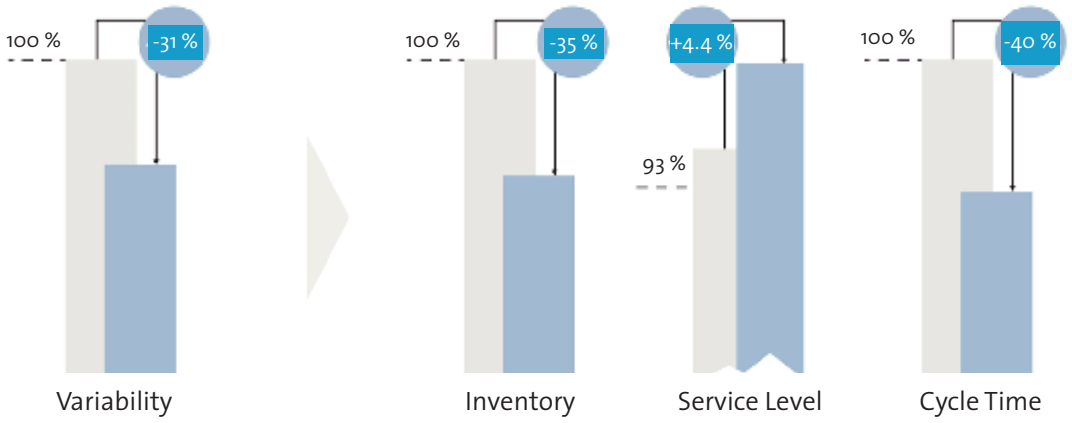
Figure 4 A step-change in variability management improves key supply chain metrics.



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Journal of Business Chemistry

Practitioner's Section

Optimization of economic conditions in the chemical, pharmaceutical and medical technology industry through a stringently interlocking procurement in the holistic business approach

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The paper discusses the findings of a survey which was conducted in 2012 by ConMoto Consulting Group among top managers in German speaking countries. The aim of the survey was to analyze the value orientation of companies from a variety of industrial sectors, i.e. to evaluate the companies' procurement. This paper briefly presents the overall findings, but the main focus is on the results of the chemical, pharmaceutical and medical technology sector. Finally, the success factors which lead to value-oriented procurement are outlined.

1 Introduction

Nowadays, if a company wants to be successful within a market and keep up with the fierce competition, it needs to focus on success factors which lead to value-oriented procurement.

Value-oriented procurement makes a substantial contribution to lowering material/non-personal and process costs, reducing the amount of capital required, and minimizing procurement risks. It also facilitates progress and innovation. Therefore, procurement should have an absolute command of three key areas: "Strategy and Innovation", "Networks, Cooperation and Integration", and "Processes, Technology and Standards".

Since procurement plays an important role in terms of increasing the value of a company, an early inclusion of procurement is substantial in the context of achieving success and not being left behind when compared to other companies. In spite of this, there is still a large number of companies which do not make full use of the success factor that is procurement, as well of its development potential.

This is also the case with companies in the chemical and pharmaceutical industry which have not fully exploited their potential in terms of achieving a higher procurement performance. In order to achieve that, they should focus on developing a procurement strategy and work on enhancing the sway factors which will be presented in the main section of the paper.

When exploring procurement strategies, certain facts should be kept in mind, i.e. that 90% of chemical production is based on carbon compounds, which are mainly obtained from petroleum derivatives, e.g. naphtha, ethylene, propylene, benzene, phenol. Important markets in the chemical industry are China and India, and these are largely responsible for the supply of the so important commodities (BIP "Best in Procurement", 2011).

2 How value-oriented is your procurement? – 2012 survey of top managers

2.1 Survey - Participants and Industrial Structure

In 2012, ConMoto conducted a survey "How value-oriented is your procurement?" among 111 companies from German speaking countries (Germany, Austria and Switzerland) to evaluate their procurement. ConMoto Consulting Group has summarized the findings of the survey, possible future fields of action and the success factors which lead to value-oriented procurement in the form of a study whose content will be presented in this paper.

The survey covered eight industrial sectors: service providers, mechanical and plant engineering, metal and electrical industry, automotive, chemical, pharmaceutical and medical technology, building sector, energy and energy suppliers and other

(this category includes companies from aviation, food and also consumer goods sectors as well as print products, yarn, furniture and packaging manufacturers). It comprised a sample of listed companies as well as small and medium-sized enterprises (SMEs).

Top managers from these 111 companies rated their procurement on the basis of eleven core statements and by applying a grading system from 1 ("very good") to 6 ("unsatisfactory"). The first nine statements aimed at evaluating the sway factors that impact value-oriented procurement, and the core statements ten and eleven were used to provide a final evaluation in terms of how satisfied the companies are with the contribution procurement makes to their success, and to explore its development potential.

2.2 Core Sway Factors

The evaluation was based on the following nine core sway factors and their underlying core statements (ConMoto Group GmbH, 2012):

1. Sway factor: Procurement Strategy
The core statement underlying this sway factor is: An up-to-date procurement strategy derived from your business strategy is in place. A development program has been defined for implementation and communicated to all parties involved in the process.

2. Sway factor: Organization and Procurement Process
The core statement underlying this sway factor is: The procurement process in your company is fast, flexible and efficient. Procurement is integrated across all stages of the process early on (cross-functional operation).

3. Sway factor: Employee Qualification
The core statement underlying this sway factor is: You are satisfied with the qualifications and the flexibility of your procurement staff.

4. Sway factor: Decision Efficiency
The core statement underlying this sway factor is: The decisions awarding contracts (prices, terms and conditions and content) to your suppliers are systematically reached and documented, with all internal partners involved in the process casting a vote.

5. Sway factor: Material Group Management and Cost Transparency
The core statement underlying this sway factor is: Your procurement department has bundled the goods and services to be procured in a systematic effective and cost-transparent manner.

6. Sway factor: Supplier Management
The core statement underlying this sway factor is: Your suppliers' potential for innovation and adding value is known and transparent. There are constant efforts to tap this potential.

7. Sway factor: Risk Management
The core statement underlying this sway factor is: Your procurement department consistently takes steps to hedge against risks, e.g. arising from volatile procurement markets or the threat of supplier insolvencies.

8. Sway factor: Intensifying Competition
The core statement underlying this sway factor is: Your company is familiar with and uses global supplier markets and specifically "develops" intense competition.

9. Sway factor: Performance Management
The core statement underlying this sway factor is: Procurement performance and/or the value contributed by procurement within your company are measured and reported to the company's management.

In spite of the negative outcome within some sectors, the survey has shown that there is still substantial room for improvement, which would eventually enhance the company's results and liquidity.

3 Results for the Chemical, Pharmaceutical and Medical Technology Cluster

3.1 Grades awarded for the Core Sway Factors

This paper has, so far, addressed some general issues related to the study design, i.e. its participants and industrial structure, but will, in terms of the above listed nine sway factors, mainly focus on one particular industrial sector, i.e. chemical, pharmaceutical and medical technology (ConMoto Group GmbH, 2012).

Every industry has its own characteristics and specific features, and so does the chemical, pharmaceutical and medical technology sector. In this industry, the qualitative requirements are very high, and thus strong supplier relationships are essential. The partial geographical bond together with choosing the adequate improvement method also present challenges which need to be taken into account in order to increase and, to the greatest

possible extent, optimize the results and findings from the chemical, pharmaceutical and medical industry which have been listed in the study.

The industrial procurement of chemical and pharmaceutical products and materials is subject to very specific and extremely critical challenges. The crude oil price coupling is reflected in the very volatile markets. The result is that a hedge is hardly possible, let alone the possibility to calculate economically.

A geographical bond, depending on location of recovery and production of materials or components, has partially a significant anti-competitive effect. The same effects come from situational and structural factors such as material losses and market adjustment. Long-term supply contracts, vertical integration (backward integration), and increasing the resource efficiency can help in this situation and ensure supply.

3.1.1 Procurement Strategy

Regarding the first sway factor *Procurement Strategy*, the chemical, pharmaceutical and medical technology cluster lags far behind – with 18% of the decision makers declaring that they have no procurement strategy, and 27% rating their procurement strategy as patchy. The results are related to the failure to develop a general coordinated business strategy that is communicated within the company, and thus an adequately communicated procurement strategy. Not only do companies have to formulate a procurement strategy, but permanently check and adjust it to ensure continuity.

Companies have no, or no consistent, coordinated and within the company communicated business strategy. Even in large companies, particularly in holding structures, there is a partial lack of a standardized strategy development process that takes into account the individual identity and culture of each subsidiary, as well as the effects of bundling in the group. This makes it difficult for the embedded business units, such as procurement, to shape their business strategies and add value. Through targeted bundling, the market power of a company can be sustained and strengthened, and lead to significant savings effects and other positive effects (earlier supply, consistent quality, etc.).

Without a general business strategy, there is no procurement strategy, and thus it is not possible to integrate effective procurement early. The majority of the following sway factors are directly related to the procurement strategy. A clear indication of this is, for example, the fact that in the chemical/pharmaceutical sector nearly 59% of the procurement volume is covered with long-term contracts. However, according to a BME study, the rate from framework agreements and catalogs is well below the industry average (37.6%) (BME, 2012).

3.1.2 Oranization and Procurement Process

In terms of the second sway factor *Organization and Procurement Process*, i.e. swiftness, flexibility and efficiency, the chemical, pharmaceutical and medical technology cluster received a "satisfactory" rating (2.8). Of the decision makers in this sector, 9% "strongly disagree" with the core statement that the procurement process is fast, flexible and efficient, whereas 9% "entirely agree" with the statement. The ratings of the majority range from "somewhat disagree" to "almost entirely agree".

The chemistry/pharmacy sector shows best practice in terms of the cost per order process. However, there is potential for improvement regarding the proportion of orders handled electronically, including statements (Procure-to-Pay). According to relevant studies (e.g. BME and University of Würzburg, 2013), the cost of the procurement process through e-procurement can be reduced by at least 30%. This is a potential that is not yet fully exploited in this industry.

The ratings in all surveyed industrial sectors show that procurement activities can be planned and managed more specifically, and such activities would eventually lead to a fast, flexible and efficient procurement process, but the organization of the procurement process should be adapted to suit the conditions of the company.

Although the early integration of procurement requires forward shifting and interlinking of procurement activities with the interface partners, the early exchange of information allows in return a more accurate planning and management of procurement activities. Particularly noteworthy is that the procurement market research and the actual procurement may run simultaneously with the planning activities, which can significantly speed up the procurement process. Through the "early procurement involvement" it is possible to identify, assess and manage risks and opportunities earlier. Best practice would be to establish a so-called "learning organization", in which events are considered as a stimulus and used in development processes in order to adapt the knowledge and capacity to the new requirements. A predictive cross-functional cooperation between users and procurement becomes a guarantee for fast, flexible and efficient procurement processes in the chemical industry. It is undisputed that there is no easy solution for this. Rather, the organizational design of the procurement should be adapted to the business realities and implemented with regard

to a particular situation. A process orientation can be implemented only within flexible organizational structures, which are already present in the company.

3.1.3 Employee Qualification

With regard to the third sway factor *Employee Qualification*, the degree of procurement staff qualifications is seen as being predominantly or mostly satisfactory. Only 9% of the decision makers in the chemical, pharmaceutical and medical technology sector are "completely dissatisfied", 46% are "somewhat/reasonably satisfied", 36% "mostly/predominantly satisfied" and 9% "completely satisfied".

Since value-oriented procurement has a substantial impact on a company's success, qualified, motivated employees are needed. This can be achieved through the creation of extensive employee qualification schemes tailored to suit the company's needs and through training courses for purchasers and groups of requisitioners.

According to a 2013 salary survey conducted by BME (BME and University of Würzburg, 2013), the chemical/pharmaceutical industry gives the highest annual salaries to procurement managers. However, this is not directly related to the qualifications of the procurement staff. The ratios of the BME study (BME, 2012) show that the costs of professional training in chemistry/pharmacy per employee are just above the industry average. If only 9% of decision makers are "completely satisfied", then there should be an increased investment in training to enhance the skills of procurement staff. Only highly qualified staff is cross-functionally accepted and early involved.

3.1.4 Decision Effiency

The results for the sway factor *Decision Efficiency* reveal that in the industry cluster for chemicals, pharmaceuticals and medical technology, 18% of the respondents do not consider themselves at all capable of making their decisions "efficiently", whereas 18% of them "entirely agree" with the statement that the decisions for awarding contracts to the suppliers are systematically reached and documented.

The overall results show that decisions are generally not sufficiently documented, and that companies should pay more attention to coordinating and introducing role assignments, ground rules and reports.

Decision efficiency and transparency is an increasingly important component of the role of procurement within cross-functional teams. When considering the ever-worsening compliance criteria, it is clearly understandable that an order should be documented and countersigned to ensure a verifiable security. Best practice is an independent decision-making body which examines relevant decision documents and agrees upon the selection. The competition among providers can thus be optimally maintained.

3.1.5 Material Group Management and Cost Transparency

Furthermore, the respondents from the chemical, pharmaceutical and medical technology sector give their *Material Group Management* a mid-table ranking (2.7). Only 9% "strongly disagree" with the core statement that their procurement department has bundled the goods and services to be procured in a systematic, effective and cost-transparent manner. The majority of the respondents, 46% "mostly/almost entirely agree" with the aforementioned statement. The overall results for this factor unfortunately show that, although companies have much knowledge of the goods and services to be procured, it is rarely documented systematically and transparently, and there is no progress in how it is structured further.

The chemistry/pharmacy sector has still room for improvement in the perception of procurement responsibility, because the volume which is influenced by procurement is the industry average, while the rate from closed frame agreements is even significantly below the industry average (see figure 1). Low rates from closed frame agreements point to weaknesses in the procurement processes or optimization of material group management. Frame agreements were made, but are not being used sufficiently by requisitioners or purchasers. Therefore, improvement and the associated assistance is also needed in this area.

3.1.6 Supplier Management

Regarding the sway factor *Supplier Management,* the findings in all sectors show that only a small percentage of the surveyed companies (4%) made full use of the innovation potential and value-added reserves of their suppliers. In case of the chemical, pharmaceutical and medical technology sector, 9% of the respondents entirely agreed with that, and half of the respondents thought there is still considerable potential for improvement in terms of how procurement can help make working with suppliers more successful.

However, the potential for enhancing efficiency and effectiveness in procurement has so far only been used by a few pioneers. Key issues, such as

supplier management, are poorly implemented. Thus, it is important to work on developing efficient supplier management systems, and strengthen the relationship between the manufacturer and suppliers by assigning them the role of value-adding partners who will eventually contribute to quality work outcomes.

3.1.7 Risk Management

The companies in the chemical, pharmaceutical and medical technology sector gave their *Risk Management* a satisfactory grade (2.6). 27% of all respondents do not believe that they are capable of taking "mostly" consistent measures to hedge against risks, whereas 18% "entirely agree" with the statement that the procurement department takes steps against risks. The overall results actually confirm that risks which companies encounter and have to deal with (risks associated with countries, branches, currencies, contracts and liabilities) are still frequently not taken into consideration in the procurement process, which eventually might lead to quality issues. Because of that, the procurement department needs to develop a strategy which would ensure consistent measures which would reduce or minimize risks. Particularly in relation to security of supply and maintenance of quality standards, a continuous monitoring of suppliers is important, as it is in respect of commodities e.g. from politically unstable regions where forecasting is difficult.

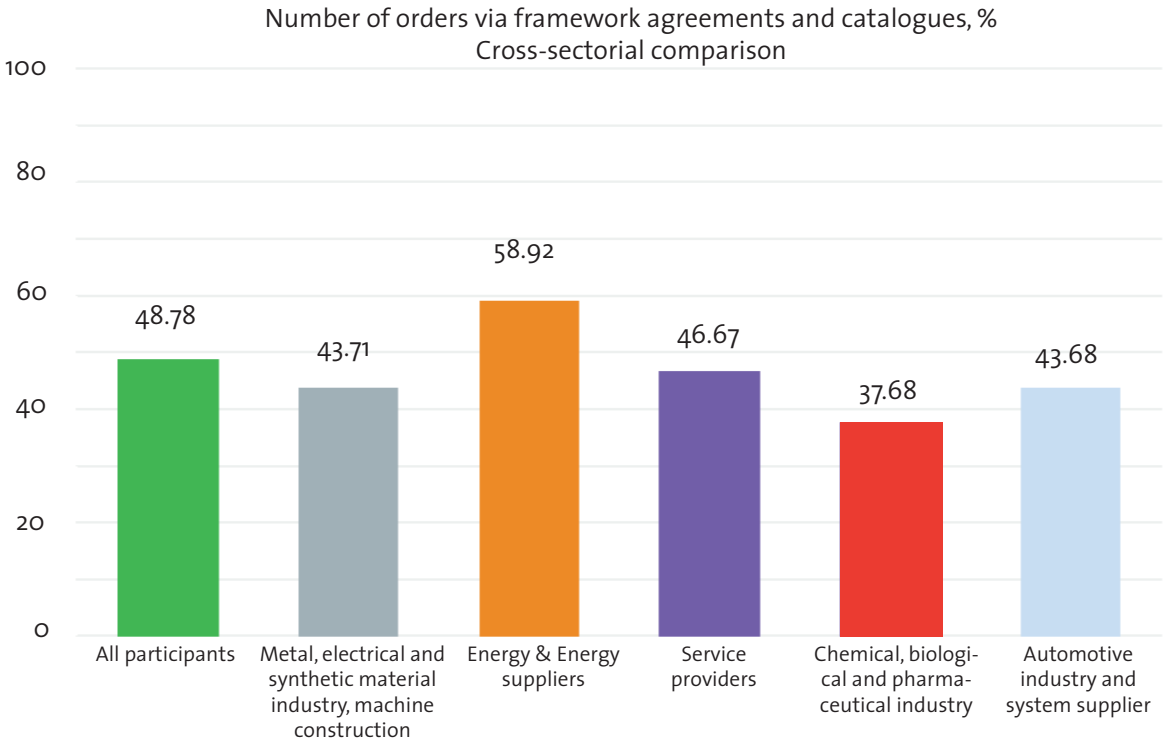
3.1.8 Intensifying Competition

The results for sway factor *Intensifying Competition* reveal that respondents from all sectors gave themselves an average grade of 2.5 which is also the average grade awarded in the chemical, pharmaceutical and medical technology sector. Of decision-makers in that sector, 18% "entirely agree" that their company is familiar with the global market and the competitiveness within that market. 36% "mostly/almost entirely agree" with that, whereas 9% "strongly disagree".

The overall results for this sway factor have confirmed that there is a substantial number of companies which still have no clear picture of their national and international procurement markets, which eventually means that some new procurement markets are not being used and that potential suppliers have not been identified. Hence, the focus should be on the use of global supplier markets and development of intense competition.

Due to a partial geographical bond, but also because of the highly specified control and apti-

Figure 1 BME Key Performance Indicators in Purchasing (adapted from BME, 2012).



tude tests in chemistry, an intensified competition is expensive, and is only feasible through early involvement of the quality, research and development department.

The low level of efficiency of online auctions and sourcing activities in chemistry/pharmacy, which is slightly above the average in the industry sectors, indicates that there is a significant untapped potential in relation to intensifying the competition. Intensifying competition also includes the use of e-sourcing and e-auction. The purchasing volume, which is handled via the aforementioned methods, can still be improved (see figure 2).

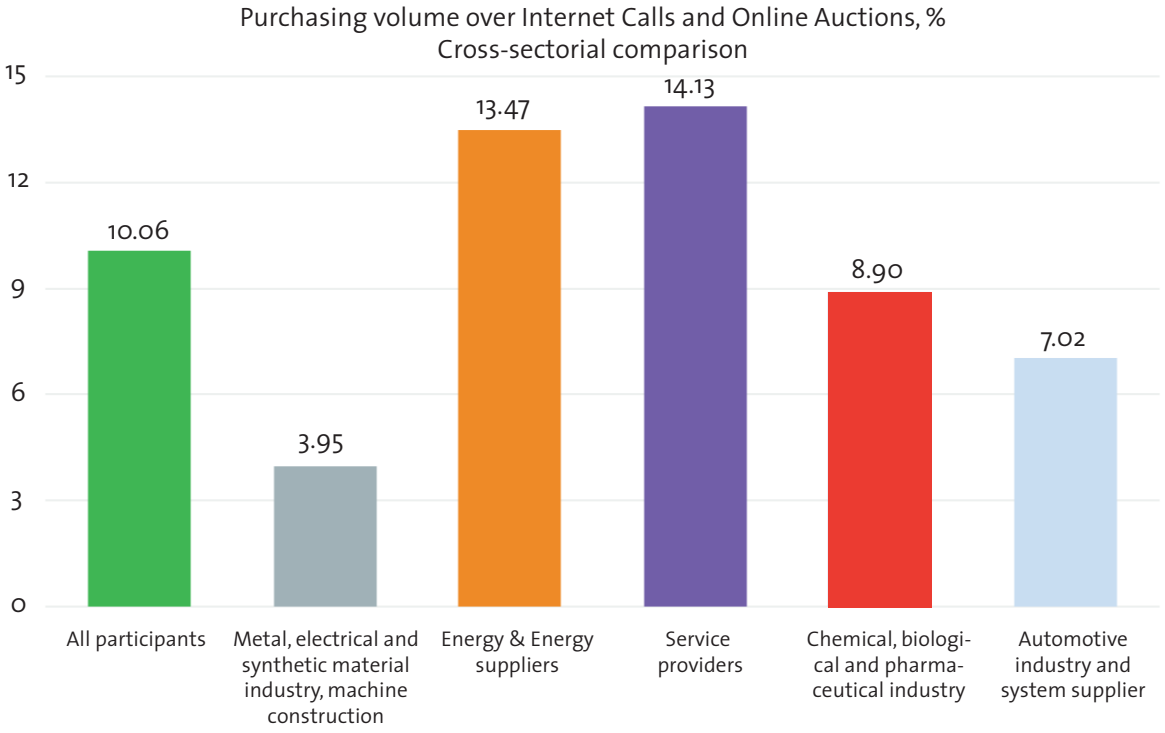
3.1.9 Performance Management

The sway factor *Performance Management* received the best average grade in the survey (2.3). It is interesting that 36% of the respondents in the chemical, pharmaceutical and medical technology sector measure and report on their procurement performance regularly every month. Only 9% never report on such performance. The overall results show that a mission for procurement is needed, and highlight the importance of measuring procurement performance systematically.

The procurement power, i.e. the value contribution of procurement is mostly properly assessed, measured and reported to the management by the procurement managers in the chemical industry. Adding value to the company's profit is perceived very well in the chemical sector by other areas of the company, and also acknowledged, because a systematic and verifiable measurement of procurement power takes place as part of controlling involvement.

Reporting instruments and stringent tracking of measures along a hardness level system are widely known, but are rarely used in many industries. However, this is not the case within chemistry. In addition, there is often a lack of an (within the company) acknowledged "Savings Guideline" in which the starting points are defined for the purposes of properly calculating and measuring procurement performance. A particular challenge in the chemical/pharmaceutical industry is the clear distinction of the starting points due to the volatile markets. Windfall profits or the increase of commodity prices such as oil are to be reported or eliminated. Costs for risk hedging purposes could be considered. Essential for this is the previously established “Savings Guideline” and a careful selection of absolute and relative indicators to identify changes and trends, and take appropriate control measures within and outside the organization.

Figure 2 BME Key Performance Indicators in Purchasing (adapted from BME, 2012).



3.2 Position in the ConMoto Maturity Model for Value-oriented Procurement

Based on the findings of their survey, ConMoto has developed a maturity model for value-oriented procurement, in which they have classified companies into different levels (ConMoto Consulting Group GmbH, 2012):

Level I "Disorganized": Procurement processes are disorganized and not clearly defined. The procurement process is often initiated by the requisitioner, i.e., it is decentralized (= Maverick Buying).

Level II "Reactive": Procurement is reactive and there is not sufficient market research. Here, procurement functions as a clerk's office and has no influence on the procurement decision, which was already pre-empted by the requisitioner. There is no active control system through procurement.

Level III "Active": Procurement structures are defined. The procurement has still no large control function. Bundling through projects and throughout the sectors does not occur. However, there are some proactive bids for required scope.

Level IV "Networked Mover and Shaker": Procurement plays an important role within the company, and is aware of the company's contacts to suppliers.
Procurement is included early in the requisition processes and may help create and control. Requirements can thus be bundled through projects and throughout the sectors. Procurement is an accepted partner both internally and in communication with the suppliers.

Level V "Performer": A sourcing committee has been established, and the decisions are reached collectively. Procurement department is a process driver. The procurement strategy is in line with the corporate strategy and the processes are efficient, coordinated and lived throughout.

Level VI "Innovative Value Provider": Decision efficiency is at the highest possible level. Procurement department shapes processes and is not only an innovator, but a value driver as well. Suppliers are also part of the innovation process. The procurement strategy is optimized continuously. Procurement is a learning organization.

In short, it can be stated that Level I-III can contribute only limitedly with their hard-earned savings. A long-term increase in value does not start until Level IV, in fact it is supported by the use of all procurement leverages:

- Increase in operating income by reductions in the cost of capital
- Targeted reductions in the cost of materials and manufacturing
- Streamlining of business processes
- Contribution to sustainable profitable revenue growth by utilizing the innovation power of suppliers and thus ensuring competitiveness
- Reduced time-to-market and reaction time.

As it can be seen in figure 3, the levels are further grouped into three categories: "Bringing up the Rear" (Level I and Level II), Midtable (Level II and Level IV) and Leading Group (Level V and Level VI).

Regarding the chemical, pharmaceutical and medical technology sector, the respondents rated their procurement as "satisfactory", and therefore this sector falls into the Level IV category of "Network Mover and Shaker" in the maturity model, which means that it has an upper mid-range ranking. It also implies that there is still work to do before it can reach the best level, i.e. "Innovative Values Provider". Another interesting fact in terms of the grades awarded for the core sway factors is that the spread of the grades for best (1.1) and worst (4.9) rated companies is most prominent in this sector.

The ConMoto Maturity Model shows the general state of the chemical industry in the overall economy among the companies surveyed. The survey of top management participants in the industry sector "chemistry" shows that there is still a lot to improve, and enormous potential could be generated through the procurement and its setting and value in the company. The conducted study has confirmed the practical knowledge gained through numerous projects in chemistry, and has given further insights in the approach and potential for improvement.

4 The Succes Factors

4.1 Twelve success factors

Based on their experience and engagement in projects, ConMoto's procurement experts have highlighted the success formula for procurement, i.e. the twelve core components which lead to first-rate value-oriented procurement. These twelve factors should be regarded in individual contexts and should be adapted to the company's specific situation (ConMoto Consulting Group GmbH, 2012).

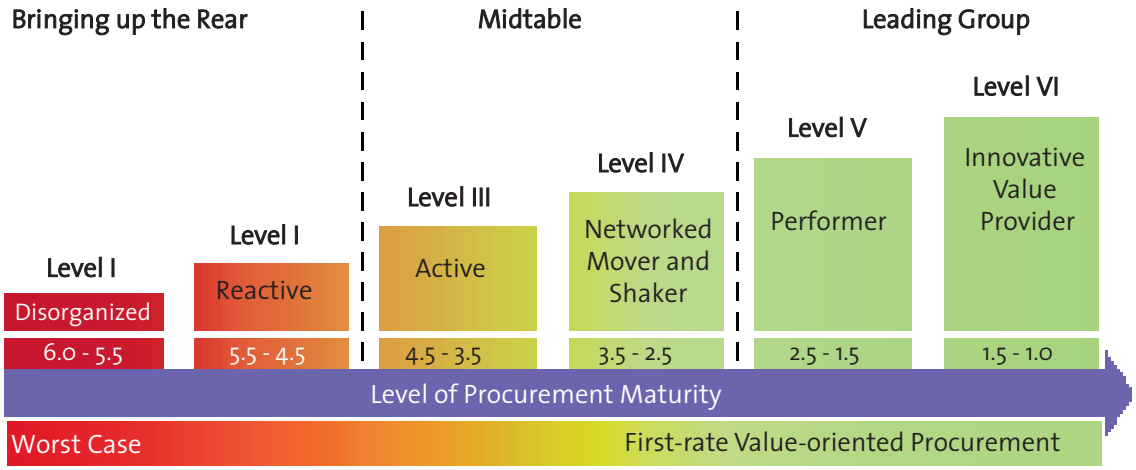
1. Strategy and Implementation Expertise
It is essential to develop a corporate strategy which will then impact the procurement strategy. Without the procurement strategy there are no common goals and thus no targeted control of the employees. The strategy elements and fields of action which need to be taken into consideration, include customer requirements, vision, mission, basic conditions, goals, responsibilities and deadlines, budget and target agreements. In order to successfully pursue these elements, it is important to report any deviations as soon as they occur. The strategy must be coordinated efficiently and be in line with the management. Adjustments and optimization must occur in the context of a learning organization.

2. Decision Efficiency
The procurement department plays an important role in the process of make-or-buy decisions, innovation, product emergence and the general procurement process. It is involved in improving decision efficiency by establishing a sourcing committee. This body needs to reach important decisions in terms of assigning tasks and awarding contracts. It is important that the committee is composed of members of departments involved in the process, and that all members are equal, so that the decisions and the impact of decisions are equally shared. However, procurement has to play the leading role in this committee in terms of processing all decision documents.

3. Financial Management
Savings guidelines are being introduced in order to measure procurement success transparently. These guidelines enable the calculation of financial procurement performance one year in advance. However, it is necessary to coordinate this calculation, which means that more departments, i.e. controlling, finance and procurement departments, need to cooperate in preparing and performing the calculation.
A commonly agreed savings guideline prevents differences in the measurement and representation of procurement services. This increases the acceptance and appreciation of procurement within a company. A savings guideline is an absolute requirement for performance measurement in relation to the objectives set in the strategy.

4. Change Management
Due to market changes, the management process also undergoes changes. This calls for the procurement department to adapt to such new requirements by changing basic conditions, processes and goals. This assumes taking internal customer requirements into consideration. New approaches should be developed and agreed upon together with the internal customer, so that these approaches are then actu-

Figure 3 ConMoto Maturity Model for Value-oriented Procurement (ConMoto Consulting Group GmbH, 2012).



ally adapted and lived. If solutions were imposed, the internal customer would feel "hindered", and assume a defensive approach. Early integration and communication are here the alpha and omega, and thus essential for success.

5. Organizational Quality
The procurement department is a learning organization, which means that it adapts its organization to its internal customers. This up-to-date approach leads to improvements regarding work instructions and organizational guidelines.
Here, procurement should be considered as the "driver seat" and again contribute to suggestions, as well as support suppliers to enhance innovation management. Suppliers can be disseminators of innovative ideas and solutions.

6. Human Resource Management
The procurement staff is an important force within the company, and therefore needs to be provided with comprehensive and specific training which will develop their qualifications. Such training will enhance the performance-oriented component, efficacy, and efficiency of the staff. In order to develop the most appropriate training and continue to play the role of active "Movers and Shakers", the procurement staff is regularly monitored and evaluated.
ConMoto has developed one such specific training program, i.e. "QAMPUS", which includes "Basic", "Professional" and "Excellence" modules. These modules help employees meet their challenges and needs. Valuable theoretical approaches are underpinned here, with many practical examples and application exercises, and upon request developed in cross-functional teams and deepened together. This fosters cross-departmental communication and understanding of the respective roles within the company.

7. Quality Performance
The procurement department monitors the quality performance through a quality assurance system, and implements the received data into its sourcing decisions. If any problems with suppliers occur, the procurement department will assist staff in quality assurance. Quality performance is also an important part of supplier management and can, in the worst case, generate very high unwanted costs (delays, complaints, product recalls, loss of reputation, etc.).

8. Supplier Management
The procurement department possesses relevant data regarding the suppliers which they receive through researching the market, i.e. the global procurement market, and reviewing competitiveness of its suppliers. The competitive environment of suppliers is used by procurement to attain competitive advantage.
But also shortening the delivery time, process improvements, quality improvements can be worked out together with the suppliers and lead to ensuring competitiveness. The development of new suppliers is part of the supplier management and is essential for a long-term cooperation.

9. Innovative Capacity
Product innovation and progress is also pursued by the procurement department. It conducts research in order to follow the developments on the supplier market. Such developments are then integrated into the company's own production development process.

10. GRC Management (Corporate Governance, Risk Management, Compliance)
The procurement department is also part of the risk management system which tries to prevent any delivery failure. The staff aims at applying regulations which will prevent potential conflicts and risks. If a deviation occurs, it is recorded and corrected. GRC plays a major role with respect to the image both internally and externally, which again is important for the area of public relations.

11. Contract Management
Regarding contractual negotiations with suppliers, the procurement department plays the central role. The contracts are stored and processed electronically, and their content is reviewed in order to check whether they are in agreement with the rules. Compliance and transparency are here the top criteria, which can only be achieved through centralized contract management. An alert function supports early renewal, extension or early termination of contracts. Duplicates and incorrect versions of contracts are prevented.

12. IT / Data Management
An IT strategy plan also enhances the procurement processes, and thus procurement staff is trained to use the latest communication systems. All data structures are up-to-date and in accordance with industrial standards. IT requirements and standards are to be agreed upon and set by an expert panel, so that they can be bundled through frame agreements and negotiat-

ed centrally. Another field can be more optimized through e-procurement, e-sourcing and e-auctions. Standardized procurement processes can be depicted through portal or cloud solutions, and safely and efficiently handled. Integrated electronic procurement systems also support the supplier management (training, evaluation, development), catalog management for C items (i.e. marginally important items for an organization in terms of their value and contribution to making profit), the spend management and contract management. E-sourcing simplifies the procurement market research, and all RFX processes[1] and e-auctions increase competition.

4.2 Success factors in chemical, pharmaceutical and medical industry

Success factors, for which the chemical/pharmaceutical industry received the lowest grades, offer conversely the largest potential for improvement:

According to the findings of the study, companies in the chemical, pharmaceutical and medical industry were ranked 8 of 8 in terms of *Procurement Strategy*, and thus placed at the bottom. Many small and midsize companies do not have or have no consistently coordinated business strategy from which, by taking into account the situation on the procurement market, the procurement strategy would be derived. The respective strategy components are to be developed together with all responsible persons in order to provide a systematic and standardized methodology and definition of success factors which the companies often lack.

Regarding the factor *Decision Efficiency* companies in the chemical, pharmaceutical and medical industry have still much optimization potential to generate, because after the analysis of the study in this area they were positioned at the bottom (ranked 8 of 8).

The most important point along the procurement process is the decision on awarding contracts to suppliers which would consider prices, conditions and a defined scope. Frequently, contract award decisions are not directly made by the procurement department, but the specialist areas make sure that specific suppliers' products and services will meet their requirements. There also might be some dependency on patents, subscription rights or tools owned by suppliers. Thus, not the best decision for the company is made, but individual interests of a department are considered. Contract award decisions are often not transparent and not sufficiently documented.

According to the study, the results for the factor *Performance Management* are much better in the chemical, pharmaceutical and medical industry. In this occasionally essential area, there is much room for improvement (rank 6 out of 8) to strengthen coordinated *Performance Management*. The mission and the function of procurement is often not clearly defined and coordinated. A „Mission Statement“ exists only rarely.

Procurement performance, i.e., the value-added procurement, is correctly assessed by responsible persons in procurement, but is rarely measured and reported to the company's management. In this way, this added value is not perceived by other business areas, nor will it be acknowledged, unless there is a systematic and verifiable measurement of procurement performance.

5 Conclusion

In the ConMoto Study, companies that operate in the chemical, pharmaceutical and medical industry show their weak points in different areas of procurement, but in turn have potential for the following areas, which will especially be reflected in the results of the company:

From the findings of the study and through an adapted methodology in the chemical, pharmaceutical and medical technology sector, the foundation of a professional procurement is an integrated, within the company coordinated and communicated procurement strategy, which takes into account the individual identity and culture of each subsidiary, as well as effects of bundling in the group. Accordingly, a systematic methodology is to be applied, and success factors should be defined.

In order to define the delegation of decision-making, an awarding body, i.e. a sourcing committee, in which all partners involved in the process would participate and have full voting rights, should be established. A distinction between, on one hand, the operational procurement and negotiation activities, and on the other hand, the actual contract award decision would be perfect. Introducing role assignments, ground rules and reports are not to be underestimated

In order to produce regular reports on procurement performance for the management of the company, reporting tools and a stringent pursuit of measures should be enhanced. However, there is also a need for a “Savings Guideline” acknowledged within the company, in which the starting points for an unambiguous calculation and evaluation of procurement performance would be defined. The status of procurement within the company is also increased through regular communi-

1) RFX is an acronym used in the sourcing marketplace, and stands for Request for Information (RFI), Request for Proposal (RFP) and/or Request for Quote (RFQ).

cation of procurement performance and the contribution to the company's profit.

Due to the interdependence of corporate strategies and procurement strategies, it is necessary to coordinate the persons involved in the procurement process, and to avoid any information asymmetries within the company. Consequently, they will develop a high sense of responsibility. It is also beneficial and has a positive impact on the process itself when authorized persons are involved from the beginning of the process.

To achieve procurement potential through the conscious development of an elaborated supplier management, is one of the key points of a procurement potential analysis. For a comprehensive optimization, together with other areas in the company, (cross-functional) integrated approaches to optimize the collaboration within the company are to be developed. Only through a long-term orientation of processes and structures towards the principles of the company and a trustful cooperation with synchronous use of the competitive situation, the full savings potential can be achieved. For this purpose, the procurement potential analysis serves the objective to observe and, for different product groups, implement the most efficient material group strategy with different levels of cooperation intensities by the staff. Prerequisites for achieving these objectives are the intensive use of the supplier's know-how and the creation of problem-solving capacity in procurement and its integration into the overall corporate image.

Likewise, the training, assessment and development of suppliers pose a far underrated contribution to generating potentials. These three levels provide the basis for quality assurance, price negotiations and deriving the consequences from the assessment. The vertical range of manufacture in companies is steadily being reduced, which leads to the fact that the procurement volume is between 40-70% of the turnover, and that reflects the increasing importance of the procurement department and supply chain management (BIP "Best in Procurement", 2011).

In spite of its significance in terms of contributing to the company's value, many companies have still not fully realized the value-added potential of procurement and, unfortunately, have not implemented a first-rate value-added procurement management system. The sooner they identify its significance, the earlier it can contribute to their own success. In order to pursue that goal, companies should focus on the success factors which will help them work towards value-oriented procurement as well as define future tasks and fields of action using the best in the industry as their benchmark. Not only cost reductions, but also quality improvements, product modifications, reduction of production, throughput, and delivery time can be initiated by procurement and performed collectively in cross-functional teams (BIP "Best in Procurement", 2011).

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Practitioner's Section

Classification of chemicals in the commercial area

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In the commercial area, classification of chemicals is not as straightforward as in the scientific area. Depending on the perspective taken, different levels can be utilized - moving from segments consisting of individual chemical compounds to the other extreme of segments only defined by the end use of chemicals. In between, there are several other levels in which both perspectives are mixed to a certain degree. The different levels are discussed along with the issues arising from their often simultaneous use. In addition, guidelines are given on the suitability of different levels for specific areas of the chemical industry.

1 Introduction

In the chemical industry, different chemical products, groups of chemicals, functions and end uses are frequently utilized as a structural and organizational framework:

- Evonik has six business units (BUs), i.e. Consumer Specialties, Health & Nutrition, Inorganic Materials, Coatings & Additives, Performance Polymers and Advanced Intermediates (Evonik, 2013).
- Typical market reports for the chemical industry cover such topics as, e.g., polypropylene, aromatics, surfactants, paint additives.
- Individual positions in chemical companies are often responsible for specific products (e.g., key account managers), functions of chemicals (e.g., technical service specialists) and end uses (e.g., end use managers).
- From the customer side, requests may come for specific chemicals (e.g., from procurement), for test materials with shared functional groups, or for materials suitable for a specific end use industry.

Taking the Evonik case as an example, the classification utilized for their products uses several levels at the same time and thus has considerable potential for creating confusion. Three of the six segments (Consumer Specialties, Health & Nutrition, Coatings & Additives) are primarily defined by specific end use industries. One (Inorganic Materials) is loosely based on chemical similarities, one on a combination of function and chemical properties (Performance Polymers) and one on the position in the overall chemical value chain (Advanced Intermediates) (Evonik, 2013). Like a shoe shop offering different departments for red shoes, for men´s shoes, for large-size shoes and for leather shoes, the approach mixes a number of different perspectives, and it is far from clear that the outcome is serving its purpose.

Practitioners in the chemical industry are sometimes only vaguely aware of these different perspectives. Even if they are aware of this issue in principle, it is not well defined how many different levels are commonly utilized and what the individual segments are on each level. The issue is further exacerbated by the tendency of chemical companies to each use their own market definitions, preferably if this allows them to claim market leadership in segments with a questionable underlying rationale.

This paper aims to describe the individual levels on which chemicals are frequently categorized. The core hypothesis is that 5 different levels are frequently utilized, also often in parallel, without the users of the classification being fully aware of the resulting inconsistencies. As a consequence, substantial problems may arise in managing a chemical business. These problems include duplication of research efforts, reduced leveraging of synergies, and unclear responsibilities for specific product-customer combinations. An additional goal of the paper is to give some guidance about which categories are the most suitable in specific situations.

In the context of this paper, a number of terms with specific definitions will be used. The term "Classi-

fication" describes the overall process of grouping different items. A classification may be done using different levels as a basis for the classification process. Therein, "Level" is the basic ordering principle which forms the basis of the classification. Within each level, there are different "Segments", the different items used to subdivide each level. To give an example: If the objective is to classify all objects in one room, this overall process is called classification. Levels (i.e., ordering principles) used to achieve this classification are, e.g., color, size, weight, use, etc. Within the level "color", different segments are, e.g., green, blue, red, etc.

2 Classification Levels

2.1 Most commonly used levels

The 5 levels most commonly used move from purely chemical ordering principles to those that are more and more oriented towards the end user industries. These levels are as follows:

- Individual chemicals (e.g., hydrogen peroxide)
- Chemical groups, i.e., groups of chemicals with chemical similarities (e.g., aromatics)
- Functional segments, i.e., segments defined by the function/property of chemicals in end products (e.g., surfactants)
- Application segments, i.e., segments defined by customer industry (e.g., paint additives)
- End use industry (e.g., coatings).

2.2 An Example

Figure 1 shows which 5 different levels might be used simultaneously for a single common molecule, BHT (2,6-di-*tert*-butyl-4-methylphenol). In this figure, only one example is given for each level – in reality, most chemicals fall into more than one segment in at least some levels (see figure. 2).

- On the first level, "Individual Chemical", BHT has a chemical name. This name describes exactly the chemical entity and is thus defined by a specific formula, CAS number, chemical properties and structure. In principle, each chemical compound has only one official IUPAC name. In reality, there is often a wealth of other commonly used names, particularly in a more technical than chemical environment.

- The next level, "Chemical Group", contains segments of chemical substances that share a common functional group or a specific other component, i.e., that from a chemical perspective form well-defined groups. For these chemical groups, there is a hierarchical (rather than a single) set of segments. For example, BHT can be described as an aromatic compound or a modified phenol. In addition, many chemicals have more than one characteristic chemical group and thus may belong to multiple segments on the same level.

- The level "Functional Segment" looks at chemicals from the perspective of a property that a specific chemical may contribute to a finished product, or a physical/chemical function a substance may have in a product. Here, the focus has already shifted away from the chemical perspective. Chemically, substances with similar function may have very different composition. For example, other common antioxidants are not based on sterically hindered phenols but on amines, unsaturated functions etc. Again, many chemical compounds will have more than one function, either because they contain more than one chemical group or because a specific chemical group has more than one function.

- The level "Application Segment" contains segments that are commonly used as market segments within chemicals, as in the example of BHT ("Paint Additive", they frequently are combinations of broad functions ("Additive") with specific target industries ("Paint")). Chemically, substances within the same application often have no relationship to others. For example, "Paint additives" also includes UV stabilizers, rheology modifiers, surfactants, catalysts etc., which share no specific chemical characteristics. As before, a specific chemical may have numerous applications. To give another example, BHT does not only belong to the segment of paint additives but also to the segments of cosmetics additives, food additives, fuel additives, pharmaceutical additives and rubber additives

- Finally, the level "End Use Industry" utilizes the customer industries of chemicals as segments. Obviously, many chemicals such as BHT also go to a variety of (different) end uses, as already indicated by the application level, and thus belong to more than one end use segment.

2.3 From many chemicals to fewer applications and end customers

For the number of segments on each level, there is a broad trend towards a smaller number towards the end use side (see figure 3). While there are tens of thousands of commercially available chemicals,

the number of end industries is well below 100, unless a very narrow definition of the industries is used.

2.4 A first draft of existing levels and segments for the chemical industry

A first attempt is made to provide a list of the individual segments on each of the 5 levels outlined above. This list will only give some examples, particularly for the first level (Individual Chemicals, where only some examples of the first few items of commercially available chemicals are listed) and the second one (Chemical Groups) but aims to be somewhat more comprehensive for the more limited number of segments on the levels of Functions, Applications and End Customers (see table 1). Nevertheless, such a list can clearly only represent an illustration of the principle at this stage. Preparation of a definite list will require a much broader participation of a variety of industry experts.

Figure 1 Levels applicable to BHT (Considering only one example for each level).

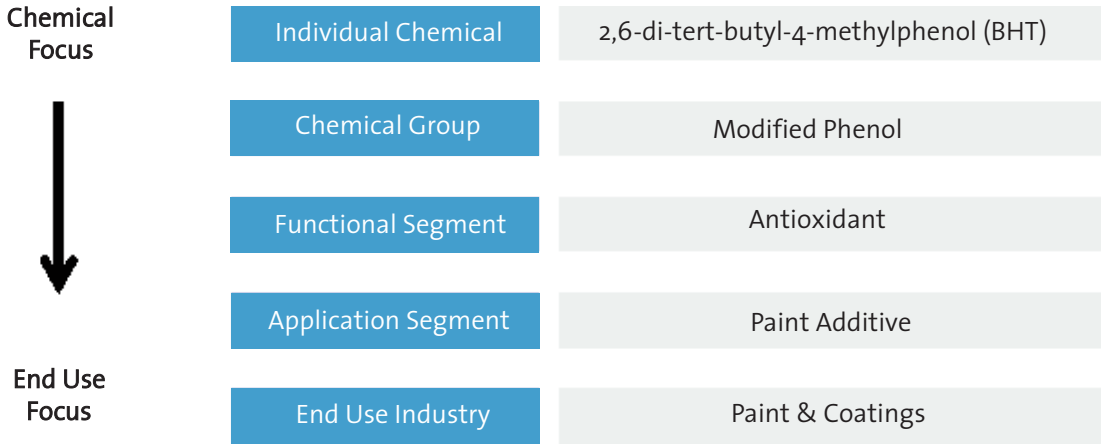


Figure 2 Levels applicable to BHT (Multiple examples are included if applicable).

Individual Chemical	Chemical Group	Functional Segment	Application Segment	End Use industry
BHT	Modifed Phenol	Antioxidant	Cosmetics additive	Cosmetics
	Phenol		Food additive	Food
	Aromatic compound		Fuel additive	Fuel
	Modified toluene		Lubricant additve	Lubricant
			Paint additive	Paints & Coatings
			Plastics additive	Plastics
			Pharma additive	Pharmaceuticals
			Rubber additive	Tires

3 Issues arising from these levels

In itself, utilizing these different levels in parallel is not an issue. However, it can easily turn into a complication if users are not aware of the obvious nonalignment of the different levels. For example, it may easily happen that within one company, there are product managers for individual products (e.g., hydrogen peroxide), for chemical groups (e.g., silicones), for functions (e.g., defoamers) and possibly also for applications (e.g., paint additives). Similar problems arise from defining relevant markets and competitors.

Coming back to the example of BHT, the question is which segment(s) this chemical should be assigned to. The answer is straightforward for the level of "Individual chemicals". It will probably also not lead to major issues on the next two levels of "Chemical group" and "Functional segment" but will obviously be much more complex on the two levels most closely related to customer industries, "Application segment" and "End use industry". Here, it will be impossible to assign only one segment to BHT unless the producing company is willing to restrict itself to only a small share of the total BHT market. The solution commonly employed to deal with these issues is to create overlaying structures of responsibilities based on different levels (see discussion below), which obviously leads to additional internal complexity.

Chemical companies use classifications for a purpose. One key objective is to decrease internal complexity and/or human resource requirements. Instead of having one person responsible for each segment on each level, which would either require a huge number of staff or massive multiple assignments to each employee, certain responsibilities are bundled. This bundling should be done in a way that it allows for some specialization of the employee responsible. This would not be achieved if the bundling was done randomly. Therefore, there is a strong case to be made for using classifications as means to allow for specialization while at the same time limiting the resource utilization.

Figure 3 Approximate number of segments for each level.

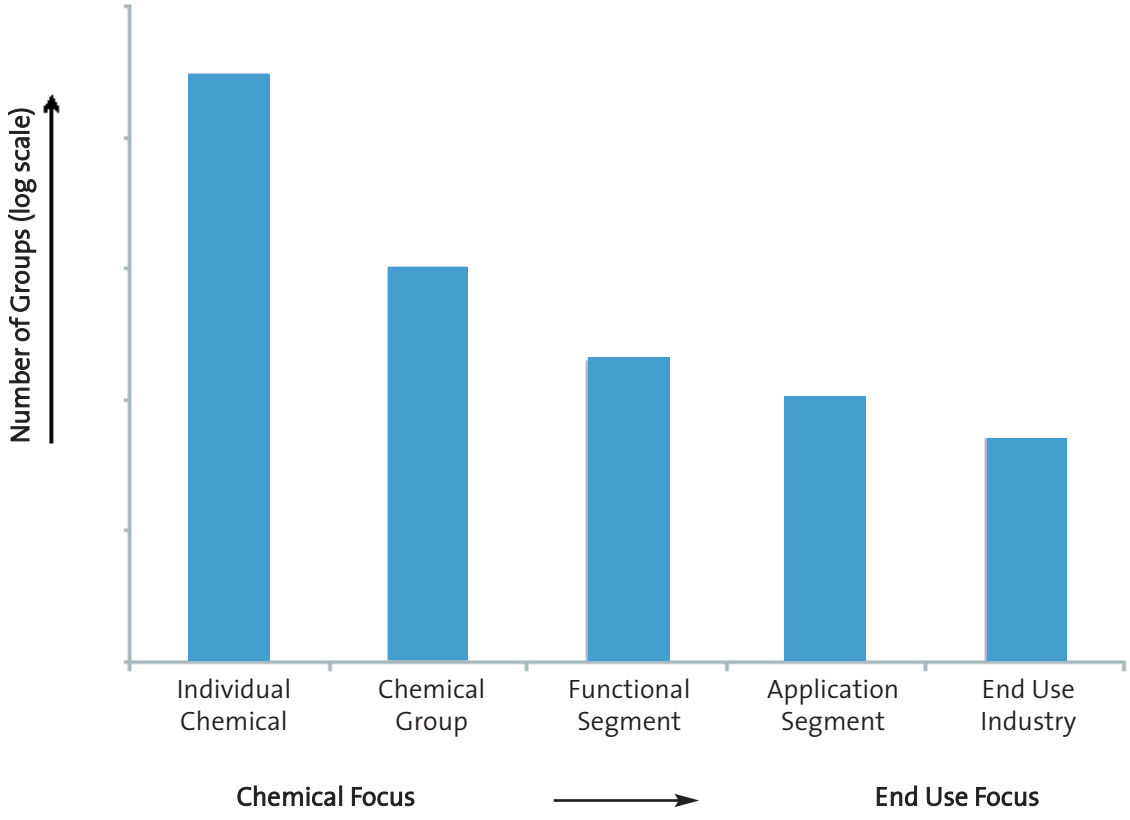


Table 1 Levels to describe chemicals and indidvidual segments on each level.

Individual Chemical (Examples)	Chemical Group (Examples)	Functional Segment	Application Segment	End Use Industry
ABS (acrylonitrile butadiene styrene)	Acrylic monomer	Absorbent	Adhesives & Sealants	Adhesives
Acetaldehyde	Acrylic resin	Accelerator	Agrochemical	Agriculture
Acetic acid	Alcohol	Adhesive	API (active pharmaceutical ingredients)	Automotive
Acetic anhydride	Aldehyde	Adsorbent	Biotech chemicals	Aviation
Acetone	Alkylamine	Antioxidant	Cleaners (industrial and institutional)	Ceramics
Acetonitrile	Aluminum compound	Biocide	Construction chemicals	Chemicals*
Acetophenone	Amine	Brightener	Consumer Care chemicals	Construction
Acetylene	Amino acid	Building block (synthesis)	Electronic chemicals	Cosmetics
Acrylamide	Amino resin	Catalyst (emission control)	Explosives	Electronics
Acrylic acid	Ammonium compound	Catalyst (process)	Feed additive	Explosives
Acrylonitrile	Aromatic compound	Chelating agent	Food additive	Flavors & Fragrances
Adipic acid	Barium compound	Colorant	Imgaging chemicals	Feed
Aluminum oxide	Boron compound	Coolant	Laboratory chemicals	Food
Ammonia	Brominated organic	Corrosion inhibitor	Leather chemicals	Fuel
Ammonium phosphate	Bromium organic	Detergent	Lubricant	Furniture
Ammonium sulfate	Calcium compound	Disinfectant	Lubricant additive	Healthcare
Aniline	Cellulose acetate	Dopant	Membrane material	Household cleaning
Anthraquinone	Chloroprene rubber	Drying	Mining chemicals	Imaging
Argon	Chromium compound	Dye	Nonwoven fabrics	Industrial cleaning
AS (acrylonitrile styrene)	Cycloalkane	Elastomer	Nutraceutical ingredients	Leather
Barium carbonate	Diisocyanate	Engineering plastics	Oil field chemicals	Lubricant
Barium sulfate	Diol	Etchant	Paints & Coatings	Medical device
Benzaldehyde	Diolefin	Explosive	Paper chemicals	Membrane

*) In this context, "chemicals" is defined as the industry producing chemicals (defined by specification) which do not have a specific application yet but rather those companies producing chemical materials for use in chemical or other products further downstream in the value chain.

Continuation of table 1 Levels to describe chemicals and indidvidual segments on each level.

Individual Chemical (Examples)	Chemical Group (Examples)	Functional Segment	Application Segment	End Use Industry
Benzene	Epoxide	Fertillizer	Pesticide	Mining
Benzoic acid	Epoxy resin	Fiber	Pharma intermediate	Oil
Benzyl alcohol	Fatty acids and derivates	Filler	Plastics additive	Packaging
Bisphenol A	Fluorochemical (inorganic)	Filling gas	Printing ink	Paints & Coatings
Borax	Fluoropolymer	Film former	Rubber	Paper
Boric acid	Gas (elementary)	Flame retardant	Rubber processing	Pesticides
Bromine	Inorganic acid	Flavor/Fragrance	Textile chemicals	Chemicals
Butadiene	Inorganic salt	Fumigant	Textile dye	Pharmaceuticals
Butanediol (1,4)	Ketone	Fungicide	Thermoplastics	Plastics
Butanol (n)	Lithium compounds	Heat stabilizer	Water treatment chemicals	Publishing
Butanone	Magnesium compound	Herbicide	Wood treatment chemicals	Sealants
Butyl acrylate	Metalorganic compound	High performance plastics	...	Solar
Butyric acid	Nitrile	Initiator	...	Steel
Calcium carbide	Noble gas	Insecticide	...	Textile
Calcium carbonate	Nylon	Insulator	...	Tire
Calcium hydroxide	Olefin (alpha)	Light/UV stabilizer	...	Transportation
Camphor	Olefin (other)	Liquid crystall	...	Utility
...	...	...	...	Water treatment
...	...	...	...	...

3.1 What level(s) should a chemical company use as a basis for classification?

Continuing the thought from the previous paragraph, this implies that classifications should generally be based on the level(s) in which the key knowledge areas of a specific chemical company are. Gains from specialization are most likely to be achieved on these levels. What does this mean in detail?

The level "Individual chemicals", in which each segment consists of only one specific chemical compound, is of somewhat limited use to most companies as it does not cluster chemical products but instead leaves them as individual units. Obviously, this is only reasonable if a company produces only a few bulk commodity chemicals such as acetic acid. It also has to be kept in mind that by using this level, there is essentially no influence of cus-

tomers and their requirements on the classification. This limits its applicability to those chemicals for which tight specifications exist and which are so common that the buyers do not expect any kind of product information apart from the specifications. Utilizing this level for classification emphasizes the production aspect of a company and is thus suited if production costs are a key success factor.

For the level "Chemical groups", a key advantage is that the perspective of the research chemist reflects the focus. Chemists involved in more basic research tend to think of molecules as assemblies of different functional groups as there are many similarities in properties and synthetic pathways between chemical compounds carrying the same functional groups. Therefore, this level is particularly suitable for fine chemicals companies as the efficient synthesis of a fairly large number of chemicals via a multitude of pathways appears to be their key knowledge. It may also be suitable for integrated production as it encourages parallel use of similar chemical resources. A danger in using this level is that problem solving may be restricted to specific chemical groups that are the focus of the company ("If you have a hammer, everything looks like a nail"). For example, a company focusing on fluorochemicals for surface treatment may neglect doing research on other chemicals that can achieve the same functions. In the long run, if fluorochemicals fall out of favor due to environmental reasons, such a company may run out of business.

The level "Functional segments" is utilized in a number of specialty chemicals companies that offer solutions to technical problems of customer problems rather than providing specific chemical components such as on the two previous levels. If a food producer is looking for an antioxidant to supplement his food preparation, it is ideal for him to have a counterpart in his supplier company specializing in this function rather than in specific chemicals. Of course, for a company this classification is only meaningful if it can indeed offer various chemicals that achieve the same function. This will then enable the customer with his specific requirements (e.g., regarding price, color, toxicity, stability, etc.) to define the best suited material in discussion with the chemical supplier. Using this level already requires a substantial amount of customer knowledge, if only to be aware of the differences between different chemicals offering the same function. For communication between technical staff of supplier and customer, this level is the most suitable.

Utilizing the level "Application segment", the requirements for understanding the customer industry are again higher. Here the ownership of the technical problem solving knowledge has shifted completely to the supplier. On the level "functional segment", it is shared between supplier and customer while on the two first levels it remained exclusively with the customer. If the preconditions are fulfilled (e.g., sufficient product portfolio, sufficient technical knowledge), this level is ideal for a solution provider in the chemical industry. Such a company would, e.g., be asked by a paint company without strong own technical capabilities to just provide the right mix of paint additives.

Finally, the level of "End use industry" is useful in two cases. First, if the company focuses almost exclusively on sales of chemicals without offering too much technical service. For example, it is a useful level for chemical distributors. This case has some similarity with the very first one, "Individual chemicals", in that primarily isolated products are delivered rather than solutions. Second, if the supplying chemical company has such extensive knowledge of the end industry that more or less all the product knowledge comes from the supplier, with the customer only providing production facilities and marketing the product. In either case, meaningful utilization of this level requires a large portfolio for the covered end use industry – in this case, the supplier may include the offer of "one stop shopping" among the competitive advantages.

To summarize the key knowledge area of a company will mostly depend on whether it focuses on commodity chemicals, specialties or providing solutions (see figure 4). The somewhat obvious result of such an analysis is that the more customer- or application-focused the chemical products are, the more an application-oriented level is suitable.

3.2 Different classifications for different functions?

Apart from basing the selection of the most suitable level on the product portfolio of a company, there is another perspective examining the issue from the viewpoint of different internal functions. Again, the question is on which level the different internal functions are most likely to have the highest level of knowledge, as specialization is likely to have the highest benefits on this level.

An analysis following this approach shows that for procurement and for production, the level "Individual chemicals" is the most suitable. Both functions primarily deal with specific chemical entities which they either procure or produce – any gains from having insight into larger segments are likely to be small. In contrast, product management can also benefit from using the levels "Application segments" and "End use industries" as product

managers in chemical companies do not only deal with the capacity planning and assignment of individual products but also with the marketing of these products. Therefore, for the sales and marketing function, these latter two levels are the most suitable as any synergies from multiple responsibilities will most likely arise from a good knowledge of the applications and end use industries. For technical staff, the levels "Functional segments" and "Application segments" are the most important as the key knowledge of this function is in the area of the interaction of chemicals with specific products and applications. Finally, the R&D function is likely to benefit from focusing on the first three levels as they are all to some extent related to chemicals and their chemical functions. Figure 5 summarizes these considerations.

However, while using different classifications for different functions will allow each function to focus on its core areas of knowledge, it can also lead to additional issues. For example, the cooperation between Marketing and R&D is likely to suffer if both functions are utilizing different classifications. In addition, even functions such as R&D, which generally focus more on the chemical than the application properties, still need to be aware of the different applications relevant for their products.

3.3 The best level for a specific company

All levels described are being used by different chemical companies, and as stated before, there is not one ideal level for all companies. However, some summarizing trend statements can be made depending on the key strength of a company.

If this strength lies in efficient production, then the level "Individual chemicals" seems to be best suited. For example, Celanese has the business units "Ethanol" and "Cellulose acetate" as these are cost-driven bulk chemicals (Celanese, 2013). If the main strength is in innovation, either the level of "Chemical groups" (for chemical synthesis) or the level of "Functional segments" (for specialty chemicals) is preferable. The level "Chemical Groups" is utilized to a large extent by Bayer MaterialScience, reflected in the business units Polycarbonates and Polyurethanes (Bayer, 2013), as well as by Arkema (BUs Fluorochemicals, Acrylic Monomers, Sartomer Specialty Chemicals) (Arkema, 2013). In contrast, the level of "Functional segments" is utilized by Clariant, e.g., as a structural basis for the BU Pig-

Figure 4 Type of chemical product and most relevant levels.

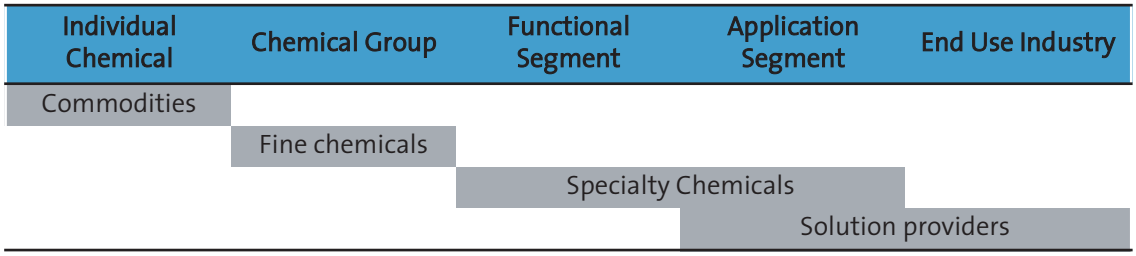
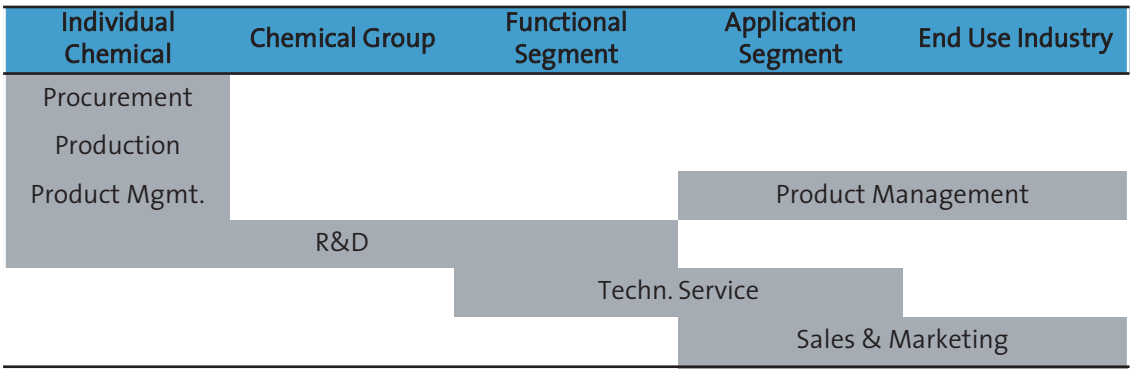


Figure 5 Functions within chemical companies and most relevant levels.



ments and the BU Catalysts (Clariant, 2013). Finally, if the focus is on the relationships to end customers, either the level "Application segments" (if technical service is important) or the level "End use industries" (if shopping convenience is important) are most likely to lead to success. The distinction between these two is often somewhat arbitrary. Lanxess has some BUs based on these two levels, for example, the BU Leather and the BU Rubber Chemicals (Lanxess, 2013).

Of course, there is always the alternative of using more than one level. The increasing popularity of matrix structures in modern chemical companies facilitates such multi-level organizations. A possible approach is to use different levels for different functions. As outlined before, levels on the left hand side are most suitable for production and procurement functions, the levels in the middle are most suitable for research and technical functions and the ones on the right hand side are best suited for sales and marketing operations. Obviously, such an approach brings its own problems. The different functions do not have a single obvious counterpart – the sales manager for paints and coatings may have to deal with 5 or 6 technical segments or in the worst case many more segments on the level of individual chemicals. Finding the right level of complexity is an issue which does not lend itself well to generalization, and indeed companies themselves tend to fluctuate between highly complex and specialized organizations (in which for example three or four of the described levels are utilized) and more streamlined ones (which possibly only use one or two levels) which are more efficient on paper but may not fully utilize market opportunities.

Though it is often hard to argue against increasing specialization and thus the use of a larger number of levels, it should be kept in mind that this often means the same number of levels cannot be utilized outside of a company´s headquarter. For example, in a smaller country utilizing the same number of levels will lead to a perplexing number of functions being held by the same three or four managers, which is highly dysfunctional in itself.

4 Further complications

It merits mentioning that the different levels described in this paper are not the only complication in describing and defining markets. Apart from the levels shown in here, which all basically are defined from the perspective of chemicals, there are other aspects such as processing steps (e.g., closed mold, cold cure for plastics) or on countries/regions. Understanding the issue illustrated in this paper will thus only partly solve the broader problem of confusing and inconsistent market definitions.

5 Outlook

As mentioned above, the suggested list of levels and segments represents only a first draft for a classification that is generally accepted within the chemical industry. Therefore, there is a strong need for discussion and review of the drafted list. In particular, agreeing on the five levels suggested (or alternatively adding or eliminating/subtracting some) would already be a major step in clarifying the overall perspective on the chemical industry. On a more detailed level, it is also suggested to refine the segments given for each level, particularly for those levels with a relatively small number of segments. A formal solution to any initial disagreements may be to add an "Other" segment on each level, though this does not solve the actual problem.

As for the suitability of different levels for specific companies and the related question of utilizing multiple levels within one company, the author suspects that an application of theories employed in other sciences such as sociology may yield further insight. This could be another fruitful approach for further research.

The author greatly appreciates feedback and/or suggestions for alternatives to the proposed classification. The overall objective is definitely not to agree on one or the other level to be the most suitable as this will certainly depend on the specific goals of such a list. However, agreement on a number of basic levels and their main segments will go a long way to increase transparency within the chemical industry, particularly to relative outsiders with limited understanding of the different perspectives currently used.

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