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Thomas Woodsen and Duy Do

NANOTECHNOLOGY COMPANIES IN THE UNITED STATES: A WEB-BASED CONTENT ANALYSIS OF COMPANIES AND PRODUCTS FOR POVERTY ALLEVIATION

Thorsten Makowski and Florian Walter

SUPPLY VALUE MANAGEMENT - A BENCHMARKING STUDY AND A NEW THEORETICAL APPROACH SHOW THAT PROCUREMENT IN THE CHEMICAL, PHARMACEUTICAL AND HEALTHCARE INDUSTRY HAS ONLY AVERAGE PERFORMANCE

Thomas K Swift

CHEMICAL INDUSTRY ACTIVITY AS A LEADING INDICATOR OF THE BUSINESS CYCLE

Editorial Board

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Contents

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Letter from the Editor

How will upcoming technological trends affect the chemical industry?

In academic journals as well as in the press, the discussion on so-called "emerging" technologies is ubiquitous. Thereby, different technologies are named but their future role for industry and everyday life can only be presumed. This uncertainty presents a major challenge for companies. How should the chemical industry and related value chains e.g. deal with technologies involving far-reaching consequences such as hydraulic fracking? As a result, it is a never-ending task for companies to stay flexible and to decide how they want to handle emerging technologies. To which extent do they engage with upcoming technological trends? Do they only adapt to changed environments and policies or is the company even at the forefront?
In 2015, trends affecting chemical-related industries such as 3-D printing, the usage of GMOs or innovative catalytic processes might be pioneering whereas in some areas, e.g. renewable energy technologies or nanotechnologies, developments seem to stagnate or technologies are falling short of expectations. It will be exciting to observe the technological trends in the New Year as well as companies' responses in order to get involved or even to stay ahead of new developments.

The research paper of this issue "Nanotechnology companies in the United States: A web-based content analysis of companies and products for poverty alleviation" by Thomas Woodsen and Duy Do deals with the social engagement of companies active in nanotechnology R&D and patenting. By analyzing information on companies' websites, the authors identify characteristics of nanotechnology-related companies which are showing initiatives to promote CSR and poverty alleviation in particular.

The first paper of our Practitioner's Section "Supply Value Management - A benchmarking study and a new theoretical approach show that procurement in the chemical, pharmaceutical and healthcare industry has only average performance" is written by Thorsten Makowski and Florian Walter. By presenting the results of a study series, the authors introduce three frameworks in order to provide a holistic approach to procurement and emphasize its manifold value creation levers. The article demonstrates specific features and gaps in managing procurement within companies of the chemical pharmaceutical and healthcare sector compared to the average results for all industries.

In the article "Chemical industry activity as a leading indicator of the business cycle", Thomas K Swift describes the set-up of the Chemical Activity Barometer (CAB). This barometer displays the development of the chemical industry's production. Due to the upstream position of chemical companies, this composite index serves as a leading indicator for future up- and downward trends in the US economy reflected by the Federal Reserve Board's index of industrial production.

Please enjoy reading the first issue of the twelfth volume of the Journal of Business Chemistry. We are grateful for the support of all authors and reviewers for this new issue.

Birte Golembiewski, Executive Editor
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Research Paper

Nanotechnology companies in the United States: A web-based content analysis of companies and products for poverty alleviation

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This study analyzes the goals, nanotechnology experience, corporate social responsibility and products of 50 USA-based companies working with nanotechnology to see if they are developing products that help low-income populations. Out of the top 50 R&D companies that publish and patent nanotechnology research in agri-food, energy and water sectors, 18 of them do not mention nanotechnology on their websites. The other 32 companies discuss nanotechnology in varying degrees. However, only two of the companies relate their nanotechnology R&D to poverty alleviation. Even though few companies refer to poverty alleviation, 30 firms of the sample have some type of corporate social responsibility programs. From the study, we cannot definitively conclude that nanotechnology is a technology only for wealthy consumers, but we do find that the companies analyzed do not give much attention to pro-poor nanotechnology.

1 Introduction

Since the early 2000s, scholars have hailed nanotechnology as a transformational technology that could change consumer products. Scientists predicted that nanotechnology would revolutionize healthcare, transportation, energy, and food and that nanotechnology products would form a USD 1 trillion market by 2015 (Roco, 2011). In 2000, the USA started a large nanotechnology initiative, and from 2000-2010, the government has spent more than USD 12 billion to fund nanotechnology research (Roco, 2011). The large focus on nanotechnology in rich countries did not escape the attention of emerging economies. Dozens of developing countries invested in nanotechnology as well and there was a chorus of scholars that discussed the potential of nanotechnology to decrease poverty (Maclurcan, 2010).

However, after 15 years of nanotechnology research and development (R&D), only few scholars have examined whether nanotechnology has positively impacted development and decreased poverty. Therefore, the purpose of the present study is to understand whether companies are developing nanotechnology products that could help the poor. Unlike other studies that detail government initiatives, we focus on the private sector because it is a key link in providing poverty alleviation technologies to the public (Meridian Institute, 2005). Scientists may create novel technologies that benefit the world's poor, but the private sector needs to develop, market and sell the technologies in order to decrease poverty. Therefore, it is important to understand the extent to which companies are directing their nanotechnology R&D efforts to products that will be used by industry, wealthy or poor consumers. To answer these questions, we analyze the websites of 50 top USA-based nanotechnology companies that patented or published research in the water, energy and agri-food sectors from 2000-2009. We want to find out if companies are discussing their nanotechnology initiatives and whether the types of products they develop and sell could benefit poor communities. Moreover, we assess whether poverty alleviation and other corporate social responsibility (CSR) programs are mentioned by the companies. If a company prioritizes CSR, it indicates that the company might make poverty alleviation a goal of their product development and sales. Through this research, we aim to add to the literature on the role of new technologies for poverty alleviation.

2 Literature Review

2.1 Nanotechnology for poverty alleviation

Nanotechnology uses matter from 0 to 100 nanometers as a primary component to create new products. At this scale, matter behaves differently; for example, nanoparticles have different conductivity, strength, and reactivity than larger particles, and as a result, scientists can use these properties to create novel products (Roco, 2011). The USA started the National Nanotechnology Initiative with an initial investment of USD 475 million in 2000 (Roco, 2011) and other countries quickly followed suit. By 2004, more than 64 countries had nanotechnology initiatives (Maclurcan, 2010). Since the beginning of the nanotechnology revolution, there was an emphasis on commercialization and scholars predicted that nanotechnology products could change a variety of sectors like electronics, pharmaceuticals, high performance materials, and safety products (Baker & Aston, 2005; Mazzola, 2003; Qiu Zhao, Boxman, & Chowdhry, 2003). Today, nanotechnology can be found in over 1,600 products ranging from golf balls to baby bottles (Woodrow Wilson International Center, 2012), and Shapira *et al.* (2011) estimate that there are about 5,440 nanotechnology companies in the USA and 17,600 nanotechnology companies worldwide (Shapira, Youtie, & Kay, 2011).

As nanotechnology increased in prominence, there have been discussions about its potential to help the poor (Meridian Institute, 2005). For example, many scientists believe that nanotechnology based photovoltaic solar cells might make the technology cheaper and more efficient, and consequently, it would be easier to install solar cells in low-income communities (Hassan, 2005). Similarly, nano-enhanced water filters could provide cheap and clean water and significantly improve the health of people in low-income countries (Meridian Institute, 2005). However, some scholars argue that nanotechnology could also have deleterious consequences for the poor. The new technology could displace jobs and create environmental hazards that would disproportionately hurt impoverished communities (Invernizzi, Foladori, & Maclurcan, 2007).

The dialogue about the potential of nanotechnology to reduce poverty and inequality falls in between two distinct philosophical underpinnings, i.e. instrumentalism and contextualism, that have different outlooks about technology's capability to help less developed countries (Invernizzi, Foladori, & Maclurcan, 2008). Instrumentalists believe that technology is a tool that changes society, and if scientists invent better technology and correctly implement it, then countries will experience economic growth and decrease poverty (Invernizzi *et al.*, 2008). Instrumentalists tend to have a deterministic view of technology because they believe that technology is good and unless something goes wrong, it will lead to further development (Invernizzi *et al.*, 2007). Instrumentalists feel confident about the potential benefits of nanotechnology to create better materials, cheaper devices, and new ways to approach science and technology (Hassan, 2005). They tend to suggest that low-income countries create nanotechnology centers of research excellence, and develop more South-South nanotechnology research networks in order to become world leaders in this burgeoning field (Hassan, 2005). Often national ministries of science approach nanotechnology with an instrumentalist viewpoint, and as a result, many countries implement nanotechnology strategies (Invernizzi *et al.*, 2007). Large countries like China, Brazil, and India make the biggest investments in nanotechnology, but smaller countries, like Uruguay, Bangladesh, and Tanzania, also have nanotechnology initiatives (Maclurcan, 2010).

Contextualists, on the other hand, question the assumption that technology will raise people out of poverty. Rather, they believe that technologies are not neutral artifacts, but "embody social relations, interest, political power, values, etc." (Invernizzi *et al.*, 2007). Contextualists are skeptical that the nanotechnology revolution will decrease inequality and poverty. They give examples of current nanotechnology products, like tennis balls or Wi-Fi blocking paint, as evidence that nanotechnology is used predominantly for luxury goods (Barker, Lespick *et al.* 2005). To further aggravate the disparity, contextualists point to patent laws. Patents help inventors to protect their research output, but at the same time, patents prevent companies in developing countries from using the technology as they are not able to afford the fees (Barpujari, 2010).

The debates between contextualists and instrumentalists created a space to study technology's impact on inequality, but there are fewer studies that find evidence of technology's impact on poverty. Recently, Cozzens *et al.* (2013) studied whether scientists develop pro-poor nanotechnologies in the water, energy and agri-food sectors. They conduct a bibliometric assessment of the literature and interviewed scientists and government officials about the effects of the technology. The authors find that there is very little evidence that nanotechnology products have helped low-income communities (Cozzens, Cortes, Soumonni, & Woodson, 2013). In another study, Woodson (2012) measures the R&D gap in nanomedicine and finds it to be more equal than reported. The healthcare literature often says that less than 10% of R&D is addressing diseases that impact 90% of the population. Instead, Woodson (2012) finds that over 90% of nanomedicine R&D is applicable for both poor and rich communities. This is primarily because cancer, a major disease worldwide, receives the bulk of nanomedicine R&D (Woodson, 2012). These studies give conflicting examples of nanotechnology's impact on poverty and highlight the fact that technology can have various consequences depending on the sector and how it is used.

2.2 Corporate Social Responsibility

This paper builds upon the work of Cozzens *et al.* (2013) to determine the extent to which corporations have developed nanotechnology products that help the poor (Cozzens, Cortes, Soumonni, & Woodson, 2013). Companies are controversial actors in poverty alleviation, and the literature argues whether for-profit organizations should aim to reduce poverty. One side of the debate argues that corporations, especially large ones, do not decrease poverty, but rather they can increase inequality because they undercut prices, put downward pressure on wages, crowd out local businesses and unfairly influence political systems for their benefit (Ans Kolk & Wesdijk, 2006). The other side of the debate is optimistic about the usefulness of corporations to alleviate poverty (Jenkins, 2005; Lodge, 2014). These scholars argue that companies train people in new skills, influence governments to provide better infrastructure and develop products that help individuals out of poverty (Lodge, 2014).

The efforts of companies to relieve poverty and implement social change are actively discussed in the CSR literature. A company that is socially responsible "has principles and processes in place to minimize its negative impacts and maximize its positive impacts on selected stakeholder issues" (Maignan & Ralston, 2002). Companies engage in CSR for a variety reasons ranging from a real sense of altruism to using CSR programs to achieve more profitable outcomes (Maignan & Ralston, 2002). Pedersen (2009) developed a model that outlines different corporate perspectives of CSR. On one end of the spectrum, companies can take a "do no harm" perspective and focus on minimizing accidents and complying with government regulations (Pedersen, 2009). This type of perspective approaches social responsibility with the minimum amount of effort. On the other hand, companies can be a "positive force" that contributes to social development. Companies with this mentality have a proactive approach to CSR, and they desire to contribute to the community and develop ethical products (Pedersen, 2009).

Scholars have studied CSR since the 1980s (Capriotti & Moreno, 2007), but only in the past five years teams have investigated CSR programs in nanotechnology firms. One research team studies CSR initiatives in nanomedicine, and find that there is a need for nanomedicine companies to focus on stakeholder engagement and public awareness in order to demystify the technology and allow the public to have an input into the development of the technology (Kuzma & Kuzhabekova, 2011a). In another study on corporate social performance, Kuzma and Kuzhabekova (2011) find that larger, older companies are most active in this sphere (Kuzma & Kuzhabekova, 2011b). Compared to large companies, smaller firms have less external pressure expertise and financial resources to start CSR programs (Kuzma & Kuzhabekova, 2011b). In a third study, Groves *et al.* (2011) examine online CSR documents from UK nanotechnology companies. They also find that large companies tend to have CSR programs, while smaller businesses do not have formal programs. In addition, many of the nanotechnology CSR programs in the UK promote "doing no harm" and implementing effective safeguards, as opposed to adding positive social value (Groves, Frater, Lee, & Stokes, 2011).

3 Methods

For this study, we examined the websites of the top 50 USA-based nanotechnology companies in the water, energy, and agri-food sectors who have patents and publications between 2000 and 2009. Website analysis has been used extensively to understand CSR programs of companies and it is found to be a valid method to understand CSR programs (Basil & Erlandson, 2008; Capriotti & Moreno, 2007; Snider, Hill, & Martin, 2003). Our first step was to compile a list of companies by searching for nanotechnology articles related to water, energy, and food in Web of Science and PatStat. To help this process, we used a nanotechnology database provided by the Georgia Institute of Technology Program in Science, Technology and Innovation Policy which includes a comprehensive nanotechnology publication and patent database created by using a multi-stage bootstrapping search process (Arora, Porter, Youtie, & Shapira, 2012). From this database, Cozzens *et al.* (2013) developed another keyword search to find articles and patents in the water, energy, and food sectors. Table 1 lists the keywords used and for a full discussion of the search

Table 1 Keywords used to identify nanotechnology publications related to energy, agri-food and water.

Energy keywords	Agri-food keywords	Water keywords
Biofuels, bio-diesel, bio-ethanol, biofuel cell, energy, efficiency, energy generation, energy production, energy storage, fuel cell, geothermal, solar photovoltaic, solar device, solar panel, solar cell, dye-sensitized solar cell, DSSC, solar energy, solar technology, solar electric, solar thermal energy, solar thermal, solar hot water, thermoelectric, wind energy, wind power, wind generation, wind electricity, wind turbine	Crop species and scientific names,animal production, poultry, beef, veterinary, beer, wine, milk, cattle, chesses, fertilizer, pesticide, herbicide, fungicide, insecticide, plant seed, seedling, soil, food production, and food packaging	Brackish water, desalination, drink, filtration, freshwater, freshwater pollution, groundwater, natural waters, pesticide remediation, reverse osmosis, saltwater, seawater, water pollution, water purification, water treatment

Table 2 List of codes used in the content analysis.

Code	Code description
Nanotechnology	What does the company website mention about nanotechnology?
Poverty alleviation/ CSR	What does the company website mention about poverty alleviation or helping the poor?
Date established	When was the company established?
Products/services	What products/services does this company provide?
NAICS code	What is the North American Industry Classification System (NAICS) code?
Purpose/mission	What is the purpose/mission of the company?
Foreign branches	Does the company have foreign branches? What is their global presence?
Sales/revenue	What are the sales/revenue of the company?
# of employees	How many employees work for the company?
Potential clients	Who are the clients of the company? Who buys their products? (industry, government, consumers)
Who benefits	Who benefits from the technology? (Rich consumers, poor[1] consumers, all consumers)
Other facts	Other interesting facts about the company. Was the company purchased or consolidated? Does the company do R&D to develop new patents or does the company purchase and hold patents?

1) For this study, any family that makes less than USD 23,850 per year for a family of 4 is consi-dered to be poor. This is the poverty-line as set by the US Department of Health and Human Services for 2014 (U.S. Department of Health and Human Services, 2014).

techniques see Cozzens *et al.* (2013). The refined nanotechnology database allowed us to choose the top 50 publishing and patenting USA-based nanotechnology companies that were active from 2000-2009.

We purposefully chose to analyze these companies as opposed to a random selection of nanotechnology firms because we wanted to focus the examination on nanotechnology companies that are active in water, energy and agri-food sectors. These sectors were determined to be especially relevant for decreasing poverty and inequality, and as a consequence, analyzing these sectors gives us the greatest likelihood of finding nanotechnologies that decrease poverty (Salamanca-Buentello *et al.*, 2005). Also, we limited our search to companies with nanotechnology patents and publications as opposed to companies that claim to be nanotechnology firms. Other studies found that many purported nanotechnology companies have no nanotechnology capabilities (Granqvist, 2013). To avoid analyzing these firms, we targeted nanotechnology companies with patents and publications. Third, we limited the search to USA-based nanotechnology companies. The USA has the most established nanotechnology sector; and therefore, it is important to understand how USA firms discuss nanotechnology on their websites and whether the technology will be accessible to poor populations (Shapira *et al.*, 2011). Moreover, this paper is a part of a larger project to examine nanotechnology's impact on inequality within the USA and South Africa. Unfortunately, there are few nanotechnology firms with patents and publications in South Africa, so we could not do a similar analysis for South African firms.

In each of the three sectors, we initially selected the top twenty nanotechnology patenting and publishing companies, and after removing companies that were not based in the USA, we had 50 companies to analyze. Similar studies also analyzed 50 selected companies (Gomez & Chalmeta, 2011). Table 4 in the Appendix lists the companies that we studied along with some key factors about each of them.

After compiling the list of companies, we read each company's website and collected information about their history, research, products, mission, number of employees, net sales, location and overseas branches. Next, we looked for information related to the companies' nanotechnology R&D and products. Some of the companies prominently discuss their nanotechnology efforts, but for most of the companies, we searched for references to nanotechnology using the company's website search engine. This ensured that we did not overlook references to nanotechnology.

Finally, we examined the company's social and poverty alleviation goals and if they use nanotechnology to achieve their social goals. We were particularly interested in how the CSR initiatives and products would directly benefit the poor as opposed to change larger macroeconomic conditions that could possibly improve the lives of the low-income communities. For example, if a company only provides services for large multinational companies (MNCs), then we assumed that the company would not make products that directly benefit the poor. But if a firm makes cheap, bacteria-resistant baby bottles, then the firm would manufacture products that directly benefit the poor. Again, for most of the companies the information about poverty alleviation was easily found on the company's website. However, to ensure that we found all references on poverty alleviation for each company, we also search for "poverty", "poor", and "charity" on the company's webpage search engine. In addition to companies' websites, we looked each company up in the LexisNexis database in order to find the company's North American Industry Classification System (NAICS) code, sales volume, profits and number of employees. The initial data was collected from June-August 2012 and it was updated in June 2014.

Once we have collected the data, we used standard content analysis techniques to analyze it. Content analysis is a research method that has been used since the 1950s to analyze text data. The goal of content analysis is to find patterns and relationships within texts in order to make inferences about the data (Krippendorf, 1980). Traditional content analysis has five main steps involving formulating the questions, selecting the sample, defining the categories, training the coders/checking for reliability, and coding/analyzing the data. However, these five steps are often relaxed in order to account for exploratory research and research based in grounded theory (Herring, 2002). Moreover, many of the procedures and assumptions of traditional content analysis do not work for web-based studies. For example, traditional content analysis requires that the data is drawn from a random sample of the population; however, it is impossible to ensure that a random sample of the population is selected on the internet. Consequently, scholars select another sampling frame that is not random (Herring, 2002). For this study, we select the 50 USA-based nanotechnology companies with the most publications and patents in the water, energy, and agri-food sectors as our sample.

Table 2 shows a list of the codes used in this analysis. At the beginning of the project, the coders agreed upon a common coding scheme and throughout the project any discrepancies were dis-

Figure 1 Size and sector affiliation the size of the 50 companies.

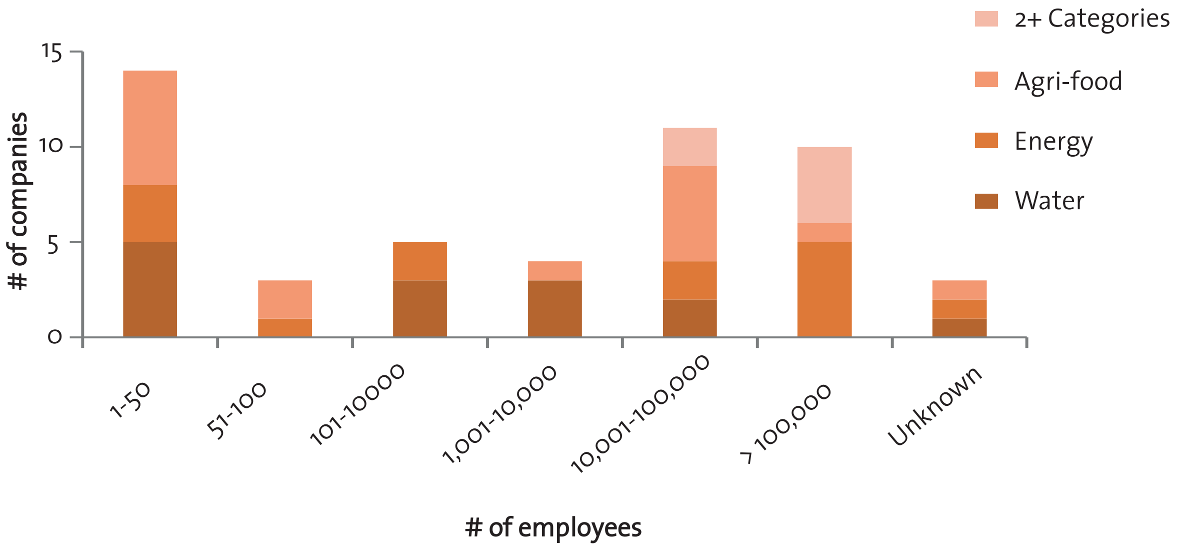

Table 3 Classification of companies by NAICS codes.

3 digit code	Description	Number of companies
111	Crop production	1
237	Heavy and civil engineering construction	1
311	Food manufacturing	1
313	Textile mills	1
314	Textile product mills	1
322	Paper manufacturing	3
325	Chemical manufacturing	9
332	Fabricated metal product manufacturing	1
333	Machinery manufacturing	7
334	Computer and electronic product manufacturing	8
336	Transportation equipment manufacturing	3
424	Merchant wholesalers, nondurable goods	4
541	Professional, scientific and technical services	9
812	Personal and laundry services	1

cussed between the coders. At the end of the project, the coding was re-verified by the principal author to ensure consistency.

Even though website content analysis has many advantages, like the accessibility and ubiquity of corporate websites, there are also issues with analyzing websites. First, a company's website does not show the effectiveness of a CSR program. Companies rarely describe the measurable impacts, the extent of the program, or the effectiveness of their efforts. Second, the companies may have developed pro-poor nanotechnologies that are not discussed on their websites. The companies may avoid discussing their pro-poor nanotechnologies because it could generate unwanted publicity or it may alert competitors of their R&D efforts. Third, websites are dynamic data sources that are constantly updated; therefore, it is possible we missed information because the website changed. We limited the impact of changing websites on the results by searching for the same information at two separate periods of time. Finally, websites are large data sources with many different papers, documents and external links. It is possible for relevant information to remain hidden. The coders spent about three hours examining each website and we extensively used search engines to ensure we collected the necessary information.

4 Results

4.1 Company Overview

The 50 nanotechnology companies in this study span a variety of industries and sectors, but the companies can be divided into two broad groups. First, there are companies that are specialized in nanotechnology. These companies are often smaller, less than 100 employees, and were founded more recently. Many of the nano-specific companies focus on solar cell technology, like Miasole, or special nanomaterials, like Nano-Tex. However, a few of the nano-specific firms do not produce nanotechnology products, but are rather environmental/technical consultants. For example, MVA provides testing services that use high powered microscopes to analyze samples. In general, the nano-specific companies focus on business-to-business sales and very few of them sell products directly to consumers. Interestingly, many of the nanotechnology-focused companies have "nano" in their company names, for example, Nanopaper, Nanosolar, Nanosys and Nano-Tex. More specific, 7 out of the 50 firms have "nano" in their titles. This was unexpected because another study found no significant relationship between a nanotechnology firm's size and their company naming strategy (Granqvist, 2013).

The other class of firms comprises large MNCs. These multinational firms span a variety of sectors such as consumer goods (Kimberly Clark and Proctor & Gamble), military and government contractors (Lockheed Martin, URS, and CH2M Hill), chemistry (Du Pont and Dow Chemical) and pharmaceutics (Pfizer and Millepore). It is not surprising that some firms like Dow and Du Pont are involved with nanotechnology since they are major chemical producers and have large R&D departments. However, the list of top USA-based nanotechnology R&D firms in the energy, water and agri-food sectors features some surprising organizations like General Motors and Phillip Morris. General Motors is one of the world's largest car manufactures and Phillip Morris is an international cigarette and tobacco manufacturer, and these firms seem not to be immediately associated with nanotechnology R&D.

Figure 1 gives a summary of the companies' sizes. Out of the 50 companies, 21 of them have more than 10,000 employees and 16 of them have less than 100 employees. The largest company in the study, IBM, has 433,400 employees, and the smallest company, Genesgues, has two employees. There are two reasons why there is a large disparity in company size among the top publishing and patenting nanotechnology companies. First, the small companies are specialized in nanotechnology, and as a result, they have many publications and patents about it. Big companies, on the other hand, have large R&D departments that can conduct R&D in a variety of fields including nanotechnology. The size of large MNCs allows them to be major players in nanotechnology even if it is only a small part of their business.

Table 3 shows the three-digit NAICS codes of the 50 companies[1] . The three biggest industries represented are "325: chemical manufacturing", "541: professional, scientific, and technical services" and "334: computer and electronic product manufacturing". Of these three industries, 541 is the broadest industrial code. Some of the companies in this category are large MNCs that provide project management, engineering design and construction services like URS Corp and CH2M Hill Corp. Other companies are small consulting firm that provide technical assistance in chemical testing. Finally, a few nano-specific companies, like Nano-Tex, are classified as scientific and technical services.

4.2 Poverty Alleviation

An important part of the study is determining whether the companies develop products that can

1) Note: The companies are classified as agri-food, energy and water companies based on their nanotechnology R&D focus. However, a company's classification to an industry via the NAICS, which depends on the overall orientation of the company, can differ.

alleviate poverty. We looked at the companies' products and determined if they would be helpful for poor, rich or all consumers. We only coded the company's products and services as benefiting the poor if they would directly help an individual below the USA poverty line of USD 23,850 per year for a family of four. Using the USA poverty line, is a sensible choice since we are examining USA companies. However, this means that many of the products and services that we code as alleviating poverty may not apply to poor people in other countries. Also, in order to make the study as objective as possible, we only coded a company as providing poverty alleviating product if there was a strong likelihood that a poor individual in the USA could afford to buy that product.

Out of the 50 companies, 21 of them sell products directly to consumers and about half of these companies, 10 companies, sell consumer products that can be purchased by low-income consumers. The other half of the companies sell consumer products that are only purchased by rich consumers.

Next, we coded the type of products produced by companies that are predominately sold to other industries and government organizations. Almost all of the companies we analyzed, i.e. 44 companies, have business to business and business to government operations. Of those 44 firms, 13 of them sell products that could help the poor even though they are not directly purchased by consumers. For example, Geosyntec Consultants specializes in water remediation, brown field development, and erosion control. The company's services are normally purchased by government agencies, but their efforts could directly benefit individuals who live in poor communities. Another firm, CH2M Hill, designs and operates large scale projects like water treatment plants, environmental remediation, and building transportation systems. Again CH2M Hill's services are normally purchased by companies and governments that are building large-scale projects. However, if these projects are implemented correctly, they can directly benefit both poor and rich communities. Note that even though the companies make products that could benefit the poor, this part of the analysis cannot determine if the company develops nanotechnology products that help low-income communities.

There are a few interesting cases that were difficult to assess the benefits of the company's products. For example, Phillip Morris produces tobacco products and their nanotechnology patents relate to technologies that produce better filters and add flavors to the cigarettes. The technology that reduces carbon monoxide inhalation could decrease health risks for smokers, but adding flavors to tobacco products to make them more desirable would increase the harmful effects of cigarettes. Similarly, the coders were unsure how to classify the product benefits of military contractors like Lockheed Martin. Some of Lockheed Martin's nanotechnology patents relate to curbing gas turbine emissions in jets and methods to build anti-ballistic structures using carbon nanotubes. These types of technologies will have both positive and negative impacts on people. In our study, we labeled 8 of the 50 companies as having an unknown benefit for rich or poor.

4.3 Nanotechnology

We found that 32 companies discuss nanotechnology on their websites. Most of the companies that explicitly mention nanotechnology are large firms, but 10 of them have less than 50 employees. The most common products that these 32 companies sell are intermediate materials like industrial chemicals. Very few companies sell the nanotechnology products directly to consumers, although some of the high-end nanotechnology products like solar panels, water filters, and fabrics could also be sold to individual consumers.

From our analysis, we find that companies portray their interactions with nanotechnology mainly in four ways. First, for some of the companies, nanotechnology is a core part of the organization's business model. Their main products and services relate to nanotechnology and the company's market advantage is that they specialize in nanotechnology research. 15 of the firms show this type of nanotechnology engagement and are thus classified as "core" nanotechnology companies.

The second set of firms mention nanotechnology on their websites and discuss their nanotechnology products; however, these companies have many other products not related to nanotechnology. Nanotechnology is a small part of their overall portfolio. We classify these firms as "periphery" nanotechnology companies. For example, 3M makes dental crowns with nano-ceramic materials, but they also make hundreds of other products not related to nanotechnology. In our sample, there are nine periphery nanotechnology companies.

The third type of firm mentions nanotechnology on their website, but they only discuss the technology as a part of R&D and as a part of future products. For example, Honeywell International discusses the potential of nano-air vehicles and nano-enhanced aerodynamic and propulsion systems (Honeywell International, 2014). Lockheed Martin says "Nanotechnology is the future of electronics, the key to creating ever more powerful and reliable devices. Our engineers and scientists are creating that future today, incorporating a wide range of advanced nanomaterials into computer chips, chemical sensors, batteries and other applications"(Lockheed Martin, 2014). These companies refer to nanotechnology as a future technology that can make a big difference, but these companies do not go into major details about current nanotechnology products.

Some companies do not have any reference to nanotechnology on their website despite having nanotechnology patents and publications. Of the 50 companies we studied, 18 do not mention nanotechnology. When we analyzed the type of nanotechnology companies that mention nanotechnology, we find that none of agri-food companies discusses the technology on their websites. This suggests that these companies are hesitant to talk about nanotechnology because the technology is not well-known by the public and might result in negative reactions.

Finally, a key question of the study is how will nanotechnology reduce poverty? It is hard to find instances where a company's nanotechnology products were key to their poverty reduction strategy. Only two companies, Konarka and Nanopaper, directly related their nanotechnology efforts to social responsibility. Both of these companies are classified as "core" nanotechnology companies. Nanopaper e.g. states that their new products will reduce the environmental impact of papermaking. Given that pollution disproportionally affects the poor (Evans & Kantrowitz, 2002), we consider their efforts as pro-poor. Konarka explicitly stated that their new nano-based solar cells could help individuals in poor and rural areas get electricity. However, Konarka declared bankruptcy in 2012 because they were unable to develop a cheap and efficient product (Kirsner, 2012).

4.4 Corporate Social Responsibilty

A main research question of this study looks beyond nanotechnology to understand whether the 50 companies are developing technologies that could alleviate poverty. Webpages are a major portal for companies to advertise themselves and espouse their values to the public. If a company prioritizes poverty alleviation, then it should appear on their webpage (Capriotti & Moreno, 2007). In our sample, 30 of the 50 companies mention something about the positive social impacts of their company or technologies. Most of the references to poverty can be found on the company's dedicated CSR page; however, a few companies discuss poverty alleviation throughout their website.

The 30 companies that mention societal impacts or poverty alleviation approach the topic very differently. In general, large companies devote significant attention to corporate social responsibility and poverty alleviation. All the companies with more than 10,000 employees say something about the societal impacts of their corporation and products. This finding matches other CSR studies that find that larger companies are more likely to have CSR programs (Maignan & Ralston, 2002). Smaller companies, on the other hand, rarely mention poverty alleviation or social responsibility. Out of the 23 firms with less than 1,000 employees, only 4 of them mention poverty alleviation or the social benefits of their technology.

The 30 companies have very different CSR initiatives. Some companies have large CSR departments focused on poverty alleviation, while other websites simply mention the possibility that their products could help the poor without any measurable deliverables. This study does not measure the size of the CSR programs, but large differences in the scope of the programs can be recorded.

A second observation is that the companies focus on a wide array of poverty alleviation and social programs. Most of the companies in our study go beyond "do no harm" CSR program and they implement proactive social strategies. Rohm and Haas states that "Corporate social responsibility encompasses all of these facets of being a good corporate citizen and more. Being responsible goes beyond just reacting to and correcting problems, and Rohm and Haas is committed to being a proactive leader in creating an environmentally and socially sustainable chemical industry" (Rohm and Haas, 2012). This company emphasizes that they have a proactive CSR program and they focus on environmental sustainability. Another company says that "Since 1963, when URS began providing technical assistance to developing countries, the company has had a continual presence in this sector. We have participated in the delivery of more than 240 development assistance programs across 47 countries. Our services include the support and implementation of infrastructure, governance, community development and institutional-strengthening activities" (URS, 2014). Again this company goes beyond "do no harm" and they are actively finding ways to reduce poverty.

Some of the CSR programs closely align with the core business model of the organization, while other CSR programs are periphery activities of the company. For example, General Motors has its own foundation and over the past 10 years, GM has spent over USD 265 million for a variety of programs ranging from scholarship funds to community development initiatives. The GM Foundation scholarship has helped poor families, but the program does not directly link to their business model of selling automobiles. In contrast, Konarka states that bringing off-grid power to developing countries was one of their main goals as an organization. Their products are thus directly linked to poverty alleviation.

5 Conclusion

This study examined the top 50 nanotechnology R&D companies in the water, energy, and agri-food sectors. We find that the firms range in size from small, nanotechnology-specific spin-off companies to large MNCs that are leaders in many technology sectors. Some companies span a variety of industries from textiles to crop production but most of the companies operate in chemical manufacturing, professional and scientific services, and computer and electronic product manufacturing.

Against the hypothesis that nanotechnology in the water, energy, and agri-food sectors could be pro-poor, we find little evidence on nanotechnology companies' websites that they are developing pro-poor products. Only 2 of the 50 companies directly associate their nanotechnology efforts with poverty alleviation and none of the companies developed nanotechnology products that only help the poor. 24 firms make products that help all consumers, including the poor, but the benefit of those products for poor communities depends on the price and distribution of the products. For example, new water filter systems could bring clean water to impoverished households, but the government has to build treatment facilities. From our results, we cannot definitively say that nanotechnology is only for the rich, but that it appears that only a few USA nanotechnology companies are actively targeting their products and R&D towards poverty alleviation. However, the public sector and non-USA-based nanotechnology firms might provide nanotechnologies that alleviate poverty. In addition, more pro-poor nanotechnologies could be developed if the technology becomes more ubiquitous. Therefore, it may take longer for nanotechnology to reach impoverished communities.

Despite the fact that few of the companies mention the potential impact of nanotechnology on poverty alleviation, 60% of the companies have statements about CSR. The CSR programs range from activities like starting a scholarship fund to giving technical assistance to developing countries. CSR statements do not automatically translate to the creation of pro-poor products, but it shows that the companies want to portray an image that they are helping society. It is desirable to see more evidence of companies using their CSR programs to develop pro-poor products by applying new technologies like nanotechnology.

6 Acknowledgments

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Appendix

Table 4 List of the 50 companies within this study.

Company	Bankrupt/ Out of business	Category	Year estab-lished	Nanotech-nology engagement	# of employees	NAICS 3
3M		Energy	1902	Periphery	84,000	424
AcryMed	x	Agri-food	-	Core	-	322
Albany International		Agri-food	1895	None	4,300	313
Alcon		Agri-food	1945	None	16,700	325
AstenJohnson		Agri-food	1882	None	80	314
Cargill		Water/Agri-food	1865	Future	139,000	111
Centocor (Janssen Biotech)	x	Water	1979	None	3000	325
CH2M Hil		Water/Agri-food	1946	Periphery	30.000	541
Clearant	x	Agrifood	1999	None	58	325
Dow Chemical		Water	1890	Periperhy	52,000	325
Du Pont		Water/Agri-food	1802	Periperhy	60,000	325
Eastman Kodak		Water	1888	Periperhy	8,800	333
General Electric		Water/Energy	1890	Future	287,000	333
General Motors		Energy	1908	None	219,000	336
GeneSegues		Agri-food	-	Core	2	812
Geocenter		Agri-food	1980	None	29	541
Geosyntec Consultants		Water	1983	Periphery	> 500	541
Harrison Western		Water	1968	None	20	237
Hewlett-Packard		Energy	1939	Future	324.000	334
Honeywell International		Energy	1885	Future	132.000	334
Hydranautics	x	Water	1975	Core	275	541
Inframat		Water	1995	Core	35	541
IBM		Water/Energy	1911	Future	433,362	333
Kimberly-Clark		Agri-food	1870	None	57,000	322
Koch Membrane Systems		Water	1963	Core	> 500	332
Konarka Technologies	x	Energy	2001	Core	25	334
Lifeblood Medical		Agri-food	2001	None	3	424
Lockheed Martin		Agri-food	1912	Future	113,000	336
Membrane Technology & Research		Water	1982	Core	32	333
Miasole		Energy	2001	None	315	334

Continuation of Table 4 List of the 50 companies within this study.

Company	Bankrupt/ out of business	Category	Year estab-lished	Nanotech-nology engagement	# of employees	NAICS 3
Millipore	x	Water	1954	Periphery	10,000	325
MVA		Agri-food	1990	Periphery	20	541
Nalco Chemical Company	x	Agri-food	1982	Core	38,000	424
NanoDynamics Energy	x	Energy	2002	Core	50	334
Nanopaper		Agri-food	-	Core	5	322
Nanoscale Materials Inc	x	Water	-	Core	-	325
Nanosolar	x	Energy	2002	Core	200	334
Nanosys		Energy	2001	Core	60	334
Nano-Tex		Energy	1998	Core	50	541
Nanoventions Inc		Agri-food	2002	None	20	333
Nextech Materials		Energy	1994	None	-	333
Pegasus Technical Services		Water	1996	Periphery	50	541
Pfizer		Energy	1849	Future	116,500	325
Philip Morris Products		Agri-food	1847	None	78,000	424
PPG Industries		Energy	1883	Future	42,000	325
Procter & Gamble Co		Water/Agri-food	1837	None	129,000	311
Rohm and Haas Company	x	Agri-food	1909	None	15,000	325
SolmeteX Inc		Water	1994	Core	14	333
United Technologies Corp		Energy	1958	None	212,000	336
URS Corp		Water	1904	None	47,000	541

Practitioner's Section

Supply Value Management - A benchmarking study and a new theoretical approach show that procurement in the chemical, pharmaceutical and healthcare industry has only average performance

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This article introduces three fundamental frameworks for procurement. Each of them targets different aspects of procurement. All three frameworks have been developed and tested in the III. Global Procurement and SCM Study which is part of the biggest global procurement study series conducted. The insights of this study and the relevant findings for the chemical, pharmaceutical and healthcare industry are discussed. The article will thus answer the question why the procurement performance of this industry is only average.

1 Introduction

The academic consideration of procurement is sometimes very simplistic. In many cases, procurement is neglected as an important value creation lever for the company or the definition and consideration is just not sufficient. This is illustrated by the fact that main definitions in academia limit procurement to a process focused department for sourcing goods in the right quality to the right place at the right time at minimum costs. Even in Porter's value chain analysis concept (Porter, 1985), procurement is seen as a supporting activity which underlines the lack of importance for procurement in this framework. Procurement is by far more important than these definitions indicate and has for decades not been the main department for aspiring young professionals. This picture has changed recently and procurement is now more and more attracting young professionals. As procurement departments develop from an internal service provider to value champions, their need for qualified employees is increasing. A need that is difficult to satisfy.

This transition of procurement and the somehow insufficient academic consideration have been the reason to analyze procurement in a detailed empirical and scientific way. Therefore, three procurement studies have been carried out to give answers on questions that have been left unanswered up to now.

Based on this biggest procurement study series, new procurement frameworks have been developed which help professionals of all industries to find their way to more value creation in procurement. These frameworks are called Supply Value Management (SVM), Supply Infrastructure Management (SIM) and the Supply Value Maturity Model (SVMM). These are interlinked and will be further introduced in this article. While Supply Value Management describes how procurement can create value for a company, Supply Infrastructure Management places the spotlight on what a company needs to achieve this value creation. Finally, the Supply Value Maturity Model assesses whether a company's procurement is rather seen as a basic internal service provider, a more mature value champion or something in between.

With the last study, the III. Global Procurement and SCM Study conducted in 2013, these frameworks could be empirically proved. The specific situation of the chemical, pharmaceutical and healthcare industry are analyzed using these frameworks to answer the question where the most important value creation potentials of this industry lie. In addition, the major differences of good and bad performing companies can be identified.

Based on the Supply Value Management, the chemical, pharmaceutical and healthcare industry shows a significant performance gap for all nine value creation levers of procurement. A specific value creation lever in this industry that is typically lower for other industries is risk (management).

The performance for all seven different aspects of the Supply Infrastructure Management is also significantly lower compared to other benchmark industries. The main performance gap for supply infrastructure, shown by the analysis for the industry, is the standing of procurement. This indicates that the main current problem for procurement departments in the focus industry is a low standing of procurement towards senior executives of other functions.

According to the Supply Value Maturity Model, the requested performance of procurement in the chemical, pharmaceutical and healthcare industry is quite high and mature. However, procurement is not able to deliver the desired value creation. This is mainly referring to the low standing procurement processes and the missing contribution to value creation by a good risk management and innovation management (with suppliers).

As these results indicate, the potential value creation levers of procurement go far beyond current typical definitions of procurement which see it as a function of acquiring the requested goods at the right cost with right quality to a determined point of time.

Before introducing the results concerning the three frameworks in more detail, the study design of the III. Global Procurement and SCM Study is displayed.

2 Study design

The III. Global Procurement and SCM Study was a follow up to the two biggest procurement studies ever conducted in 2009 and 2011 with about 1,800 participants from 82 countries. It was conducted by the Kellogg School of Management (one of the Top 5 Business Schools of the world), the American Purchasing Society, the International Chamber of Commerce and the Valueneer GmbH.

Based on a questionnaire with 47 questions, important topics of procurement were analyzed. The questions were clustered to the following procurement related topics:

1) Trends
2) Strategy
3) Organization, Controlling and Processes
4) Ethics and Chief Procurement Officer (CPO)
5) Risk Management.

Exemplary questions that were asked in the previous studies as well as in this study are:

- Do you have a communicated procurement strategy in your company?
- Do you have a specific controlling of procurement activities in your company?
- Are procurement activities in your company standardized and documented?

New questions focusing on trends and risk management were included in the III. Global Procurement and SCM Study. To put an additional emphasis on sustainability and ethics, questions such as

- Which instruments do you use to create a sustainable procurement?
- Do you feel pressured at your company to behave in an unethical way to better achieve targets and goals?

were added.

For this study, more than 5,000 top executives of renowned international companies were contacted. In total, the III. Global Procurement and SCM Study can refer to participants from 555 companies from 66 countries around the globe. The entire study series had participants from 94 countries. Companies from the chemical, pharmaceutical and healthcare industry are representing 9% of the participants in the last study. The study participants originate from all continents. North America, Asia and Europe are represented to a similar extent. Also companies from Africa and South America participated and account together for around 16% of the sample. The study examines all different business sectors and company sizes.

The study covers all relevant decision levels, i.e. senior managers and procurement experts. Therefore, important operational and strategic questions can be analyzed from a complementary point of view. The data was gathered from July 2013 till December 2013.

Against the background of the III. Global Procurement and SCM Study, the insights on the three procurement frameworks will be described in the following for all industries in general. Additionally, the industry analysis for the chemical, pharmaceutical and healthcare industry will be shown in particular.

3 Supply Value Management (SVM)

General definitions of procurement limit its importance typically to a supply chain perspective. In this context, procurement is often defined as the acquisition of goods and services at the best possible total cost of ownership to meet the needs of the purchaser in terms of quality and quantity, time and location (van Weele, 2010). From our perspective, these definition are not complete as they neglect important value creation levers of procurement. The operational perspective of procurement is essential, but it shows just a part of the full value creation potential of procurement. A definition of procurement should take a more strategic perspective into account. How can procurement support the strategy of the company?

According to Porter (1996), (1) strategy is a logical concept to achieve a higher financial performance (e.g. ROCE) compared to competitors by (2) a unique value proposition, (3) a different tailored value chain, (4) activities that fit together and reinforce each other, (5) involving clear trade-offs and thus enabling (6) sustainable advantage. If procurement should support the overall business strategy, similar aspects have to be involved when defining the procurement strategy. Taking into consideration Porter's definition of strategy, the following attributes could be derived easily for a company's procurement strategy:

1) Logically connected to the goal of long-term superior financial performance
2) Maximizing value creation from supply and suppliers
3) Fitting the company's positioning and strategy
4) Adapting to other parts of the entire value chain
5) Defining clear trade-offs within potential procurement goals
6) Striving for sustainability with continual improvement

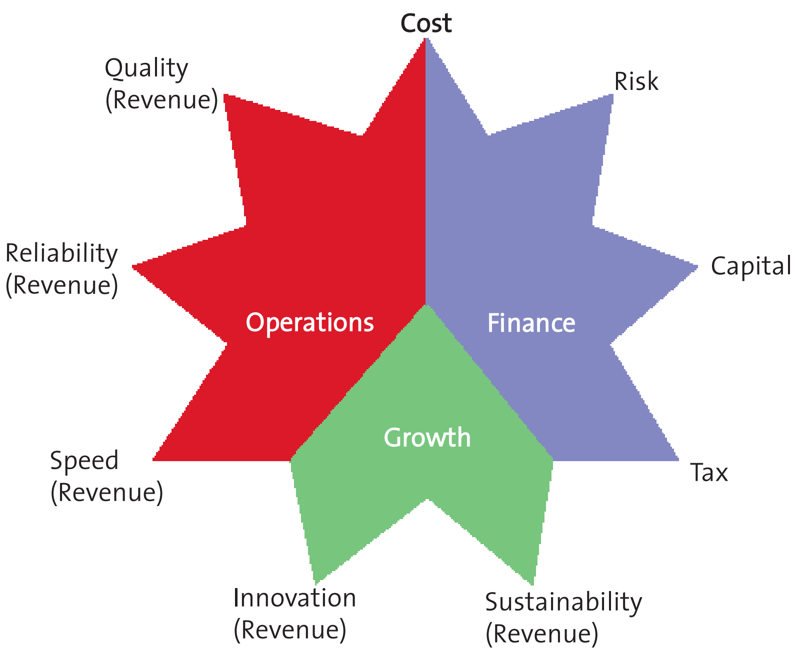
If the goal of any strategy is to achieve a higher financial performance, one starting question for any procurement strategy should be, how procurement can influence financial performance.

Generally speaking, procurement can influence a company's financial performance by five key KPIs: margin, revenue, risk, capital and taxation. So, procurement can help a company in order to achieve a better financial performance by better managing Total Cost of Ownership (TCO) leading to higher margins, by increasing revenues through procurement, by reducing supply risks, by fewer required (working) capital and lower taxation.

These five key levers define the complete set of aspects how procurement can influence the financial performance:

Margin: The way in which procurement is directly influencing a company's margin is by its various costs such as material costs, service costs, process costs and personal costs. Because procurement typically spends the largest cost block, procurement has a huge lever on a company's total cost. Margin will therefore be called 'cost' in the Supply Value Management framework illustrated in Figure 1. Due

Figure 1 The nine value creation levers of Supply Value Management (SVM).



to its high importance as a value creation lever, it is allocated to the operational as well as to the financial perspective of the SVM.

Revenue: The most important functions of a company influencing revenues are typically not procurement but sales, marketing or R&D. But procurement's effect on revenue should not be neglected. Additionally, for a procurement person it is very hard to estimate how and to which extent he or she can influence a company's revenue. Therefore, 'revenue' has to be represented by a set of levers which influence revenue and are easier to understand, observe and influence from a procurement perspective.

The first perspective on revenue is an operational one. The quality of the supplied goods definitely has an influence on the revenue. Additionally, procurement has an influence on whether important materials are available or not. Suppliers who can react fast and flexible are helpful for boosting sales when clients or business situations require short term adaptations to changes. Thus, 'quality', 'reliability' and 'speed' form the operational perspective on revenue in the SVM framework.

There is a second growth perspective which is also related to revenue and originating from differentiation. This perspective is associated with sourcing more innovative or sustainable products. While there is a positive effect of more sustainable products, there might as well be a negative effect if not considered, e.g. by negative press because a company is sourcing from a supplier that uses child labor. 'Innovation' and 'sustainability' represent the growth perspective in the SVM framework.

As revenue can be broken down to a growth and an operational perspective, the influences are represented by quality, reliability, speed, innovation and sustainability in the SVM framework.

There is a third perspective in the SVM called the financial perspective. It is represented by 'risk', 'capital' and 'tax' in the framework. As these are common terms from a financial perspective and easy to understand, a substitution with other more observable terms from a procurement perspective is unnecessary.

Risk: Procurement can influence a company`s risks to a large extent. The volatility of material costs or exchange rates are examples for that. Additionally, it can be affected by the risk of suppliers going bankrupt or by the risk to be hugely affected from natural disasters or political unrest.

Capital: Procurement has mainly two ways to influence the capital needed: Accounts payable and stocks. Both are part of the working capital and influence a company`s liquidity. Moreover, procurement influences important make or buy or buy or lease decisions which have an effect on the need for capital.

Tax: Procurement can also influence a company's taxation e.g. by using procurement offices in countries with lower taxation. Besides a potential negative press on doing or not doing so, this is influencing the financial performance of a company.

From these five key levers of procurement on the financial performance of a company, nine important value creation levers can be derived. These value creation levers are:

1) Cost - Key lever: *Margin*
2) Risk - Key lever: *Risk*
3) Capital - Key lever: *Capital*
4) Tax - Key lever: *Tax*
5) Sustainability - Key lever: *Revenue*
6) Innovation - Key lever: *Revenue*
7) Speed - Key lever: *Revenue*
8) Reliability - Key lever: *Revenue*
9) Quality - Key lever: *Revenue.*

These nine value creation levers together form the SVM illustrated in Figure 1. This model has been developed and tested on the background of the procurement study series. The Supply Value Management is a framework to handle trade-offs and align the procurement strategy to the overall business strategy. Based on the SVM, a company can set up the main value creation levers for procurement, derive KPIs and e.g. decide which suppliers to choose. There might be a situation where suppliers have the same or similar cost for a good or service that is about to be bought. Additionally, qualitative aspects are also equal. However, the suppliers perform different on speed and reliability. As the importance for these two aspects has been defined in the SVM, the decision can be made more easily as either speed or reliability has been given a higher importance for sourcing decisions.

The framework is considering by far more aspects of procurement than typical supply chain and operation focused definitions of procurement. The operational perspective is of course an important one and therefore also considered in the framework, but there are additionally the financial and growth perspective that need to be taken into account.

Figure 2 Comparison of Supply Value Management (SVM) for all industries and the chemical, pharmaceutical and healthcare industry.

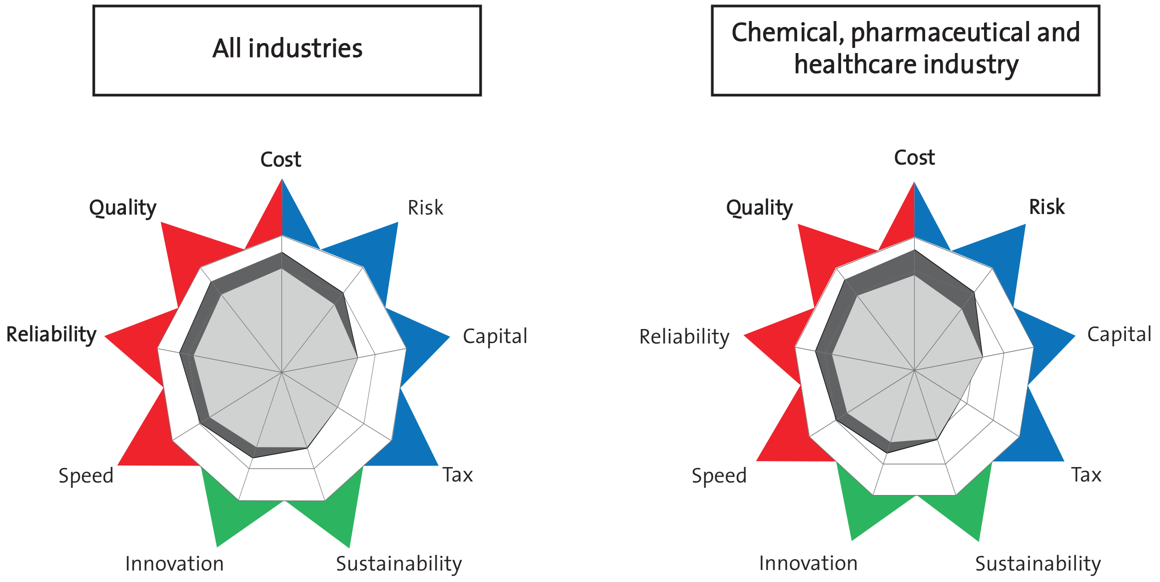
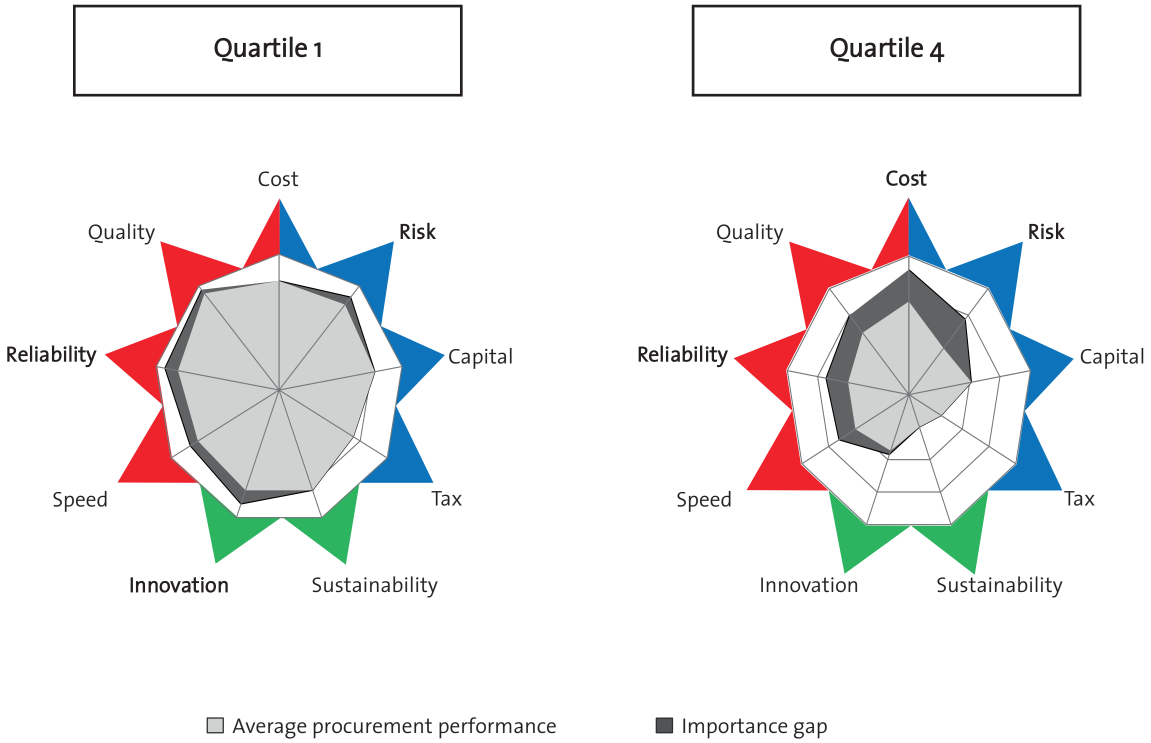


Figure 3 Comparison of Supply Value Management (SVM) for companies of the chemical, pharmaceutical and healthcare industry in quartile 1 and 4.



3.1 Supply Value Management in the chemical, pharmaceutical and healthcare industry

Based on the results of the III. Global Procurement and SCM Study, the performance regarding the nine value creation levers of all industries can be compared with the performance of the chemical, pharmaceutical and healthcare industry. Performances for all industries are illustrated in Figure 2. Shown in light grey is the average performance of the cross-industry benchmark for all participants in the study regarding the ability to create the specific value within procurement. The dark grey area shows the gap between the current performance and the aspiration target of each of the nine value creation levers. If the dark grey area is large, there is a significant difference between aspired and achieved performance for a value creation target.

By looking at the Supply Value Management for all industries, the highest gaps are shown in the areas of cost, quality and reliability. Although these topics might be seen as the 'old perspective on procurement', the average of all companies is still struggling in achieving the aspired value creation targets. In addition to the mentioned levers, there is also a relevant average gap for risk, speed and innovation. Regarding capital, tax and sustainability, the average of the participants state that they do not have a huge gap between performance and importance for these levers.

Taking a look at the analysis for the chemical, pharmaceutical and healthcare industry shows that the importance gap regarding most of the value creation levers is higher than compared to the cross-industry analysis. This means that in comparison to the industry average, this industry has a much higher performance problem regarding desired and achieved value creation. In addition to that, the importance and subsequently the required value contribution for the value creation levers are expected to be higher compared to an analysis for all industries.

The highest gaps for value creation are in the fields of cost, quality and risk. While reliability already shows a significant gap, the gap for risk is even higher. The high importance of risk management in the chemical, pharmaceutical and healthcare industry should not be surprising. However, the large gap for such an important topic in this industry is an important negative indicator. Additionally to the already mentioned aspects, the industry can improve on reliability, speed and innovation.

Taking a closer look at the performance and importance in the chemical, pharmaceutical and healthcare industry for good and bad performing companies regarding procurement shows significant differences for the Supply Value Management. The different importance and performance for quartile 1 and quartile 4 companies are illustrated in Figure 3. The companies have been grouped into four quartiles based on their average procurement performance. Quartile 1 therefore represents participants with a good procurement performance. Quartile 4 comprises companies with the worst procurement performance. Each quartile represents 25% of the survey participants.

It becomes obvious that the problems for good and bad performing companies in the chemical, pharmaceutical and healthcare industry are quite different. Good performing companies from this industry meet their cost targets and can refocus their attention to areas like quality, reliability, risk and innovation. Companies from quartile 4 do not achieve their targets regarding their most basic KPI, i.e. cost reduction. As a result, they have fewer resources to focus on other value creation levers. Subsequently, they have a bad performance concerning quality and reliability and a very bad performance regarding risk (management) compared to their (already low) aspiration.

Another interesting aspects is also revealed. Growth aspects in general seem, on average, to be less important for bad performing companies. The good performing companies even see innovation as one value creation lever which they need to improve while this is almost completely unrealized by bad performing companies. What both quartiles have in common is the fact that they state they need to improve on risk.

In total, the importance of all value creation levers for good performing companies in the chemical, pharmaceutical and healthcare industry is significantly higher and good performing companies consider more different aspects they need to work on.

4 Supply Infrastructure Management (SIM)

Supply Value Management covers all levers by which procurement directly creates value for a company. But there are indirect ones as well, i.e. aspects that define procurement's infrastructure. Therefore, another framework has to be developed. This framework considers the supporting aspects and resources of procurement for value creation. This framework is called Supply Infrastructure Management. The SIM framework has like the SVM framework been set up on the empiric findings of the three global procurement studies conducted.

There are seven different aspects that this framework takes into account which can be grouped into four different areas: strategy, tools, people and organization. It is noteworthy that this framework is not about direct value creation. Each of the aspects that is part of this framework is supporting or reinforcing the value creation levers of the SVM, but none of the aspects is creating value by itself. For example, standardized processes, a new IT systems or more or better employees are not creating any value by their existence. However, they can provide the necessary resources, transparency etc. for procurement to e.g. better achieve cost targets by higher transparency or reduced time and effort spent on managing tenders.

The four areas of procurement's infrastructure are described in the following:

Strategy: Based on the performance analysis of the study series, strategy is the most important aspect supporting the value creation of procurement. The strategy defines clear trade-offs for the nine value creation levers and provides guidance e.g. on whether quality is more important than cost or vice versa. This is highly important as not all value creation levers have the same importance for a company. Once these trade-offs are defined, they enable the company and procurement to better create value as they support the decision-making process. A lot of companies lack these and have problems to find optimum solutions when they have to choose between suppliers with different advantages and disadvantages. Additionally, it is important to link the procurement strategy to the overall business strategy.

Tools: The two aspects of the area 'tools' are controlling and processes. The controlling enables procurement to measure its performance and also shows the value contribution to other departments. The improvement of processes e.g. by standardization frees capacity that is currently blocked by operative tasks which are not creating any value for the company. The capacity can then be used for more value creation tasks e.g. by leveraging new potential suppliers for value creation.

People: The CPO and the employees are of course an essential part of the supply infrastructure. And for a lot of companies today, lacking good people and a strong leadership in procurement are main bottlenecks when willing to improve procurement performance and realize increased value creation.

Organization: The organizational structure of procurement does as well influence how procurement's infrastructure can contribute to a better value creation. For example, the standing of procurement is important as it influences at which process step procurement is involved in buying decisions. A centralized or decentralized procurement organization also affects how procurement can or cannot create value e.g. by bundling supplies.

Figure 4 The seven areas of Supply Infrastructure Management (SIM).

The framework of SIM is illustrated in Figure 4 and consists of the following seven areas:

1) Strategy
2) Controlling
3) Processes
4) Leadership
5) Employees
6) Structure
7) Standing.

The Supply Infrastructure Management is an easy to use framework illustrating the current and aspired status quo for the supporting aspects of Supply Value Management. Therefore, the two models should ideally be considered in combination and not isolated.

4.1 Supply Infrastructure Management in the chemical, pharmaceutical and healthcare industry

The analysis of the III. Global Procurement and SCM Study shows that there is a significant gap between importance and performance for all seven supporting aspects of the SIM for all industries. As for the Supply Value Management, the dark grey areas indicate the gaps which show that the average performance is lower than the average importance. In case there is no dark grey area, the importance and performance have been evaluated as being equal.

As illustrated in Figure 5, companies perform best regarding processes, controlling and (to a lower extent) strategy. This is not surprising because the same definitions that focus the value contribution of procurement in the areas of cost, quality and reliability define the core of procurement by its nature of optimizing material flows. Taking this process focused approach as a starting basis for procurement is very common across all industries.

The gap is highest for employees, structure and leadership within the cross-industry sample. The analysis illustrates one of the major problems that procurement is currently facing. In general, there are too few employees with the right skills available and subsequently many companies state that they would need additional resources. In addition, employees are rather not having the expected qualification level. Most companies also miss an incentive structure supporting the value creation of procurement e.g. in the field of cost. Providing incentives in reliance to cost saving targets would be a smart approach to increase the performance of these employees and procurement as a whole.

But also procurement's interface to senior executives is something that needs to be improved. Procurement many times misses to have a voice in the board of directors which is an indication on the limited power procurement has in a company. This fact is also linked to the leadership capabilities of the CPO. Strong CPOs will manage to improve this interface and direct more attention towards procurement. The leadership capabilities are also linked to the fact that the CPO often originates from operations. This would shape the mindset of the CPO to a large extent, so that the operational value creation levers push other levers into the background. Subsequently, some value creation potential is left unexploited.

The challenges for the chemical, pharmaceutical and healthcare industry are similar to the overall industry sample but showing different centers of gravity. However, what becomes obvious from Figure 5 is that the performance gaps for most aspects of SIM are higher than in the analysis of all industries. Only for employees and leadership, there is a performance gap that is not as high as for the cross-industry sample. As indicated for the SVM, the gaps for the chemical, pharmaceutical and healthcare industry are also for the SIM significantly higher than for the cross-industry average (with exception of employees and leadership). The highest benchmark gaps are present in the fields of controlling, standing and structure. Most obvious, the standing of procurement in this industry is below the average cross-industry benchmark.

As indicated earlier in this article, the lower standing of procurement in the chemical, pharmaceutical and healthcare industry should not be a big surprise as the standing of departments like sales and especially R&D is quite high in this industry. The interface to senior executives is also not as good as in the cross-industry benchmark. This might to some extent also be related to the gap existing for controlling. Once the value contribution of procurement is not measured and communicated transparently, the standing is weakened. Although all aspects of the SIM show significant performance gaps, the gaps for employees and leadership are smaller than for the cross-industry analysis. The chemical-related sector with a lot of large multinationals seems to be better than average able to attract good people in sufficient numbers who are led by a CPO with adequate leadership capabilities. Nevertheless, the chemical, pharmaceutical and healthcare industry still needs to improve on these aspects.

A closer look at what good and bad performing companies in the chemical, pharmaceutical and healthcare industry are doing differently is illustrated in Figure 6. The good performing companies of this industry do not show any significant benchmark gaps in the field of SIM. They are meeting

Figure 5 Comparison of Supply Infrastructure Management (SIM) for all industries and the chemical, pharmaceutical and healthcare industry.

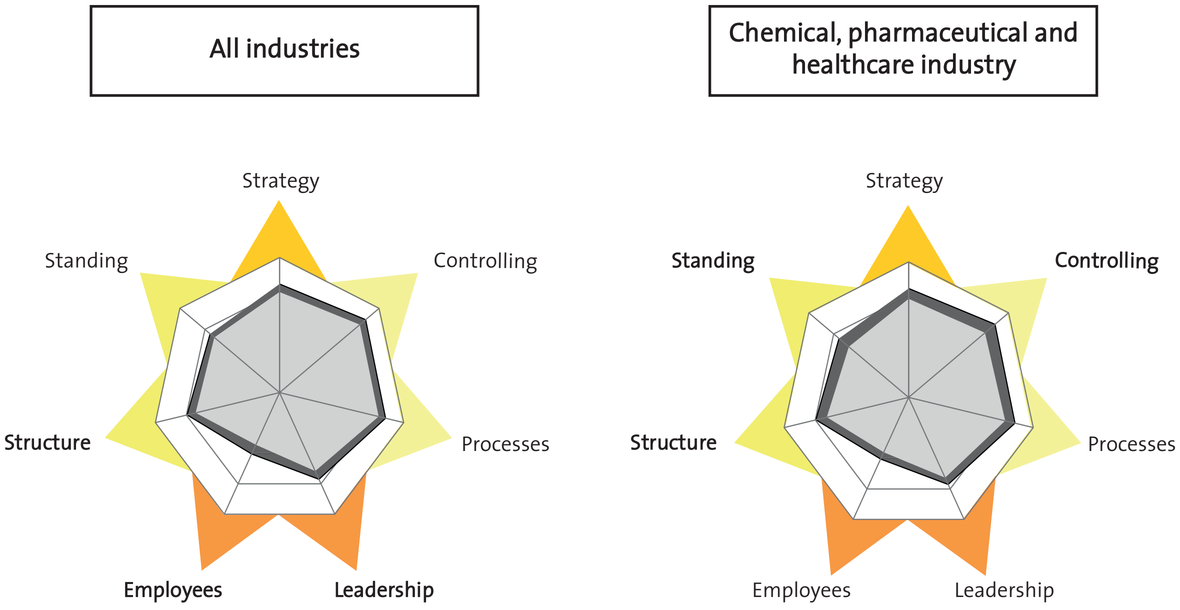
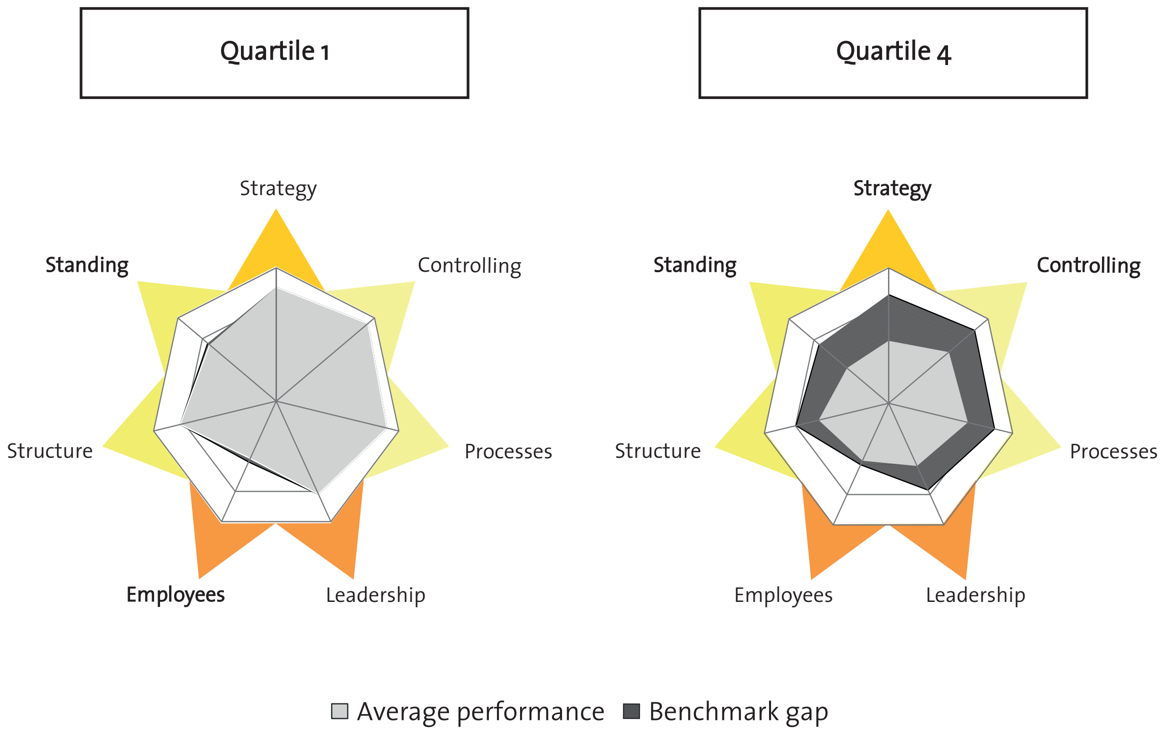


Figure 6 Comparison of Supply Infrastructure Management (SIM) for companies of the chemical, pharmaceutical and healthcare industry in quartile 1 and 4.



almost all performance targets for the seven aspects of SIM. Only slight necessary improvements for standing and employees for the top performers can be identified.

The picture for the bad performing companies in the chemical, pharmaceutical and healthcare industry is completely different. These companies show a very high benchmark gap for all areas of the SIM. These gaps are highest for strategy and standing. If we compare this with Figure 3, we can identify that bad performing companies do not seem to really have a procurement strategy as procurement for them mainly focusses on two aspects, i.e. cost and quality. Again, the gap for employees is even quite low for bad performing companies which underlines the fact that employees do not seem to be one of the major infrastructure problems for this industry.

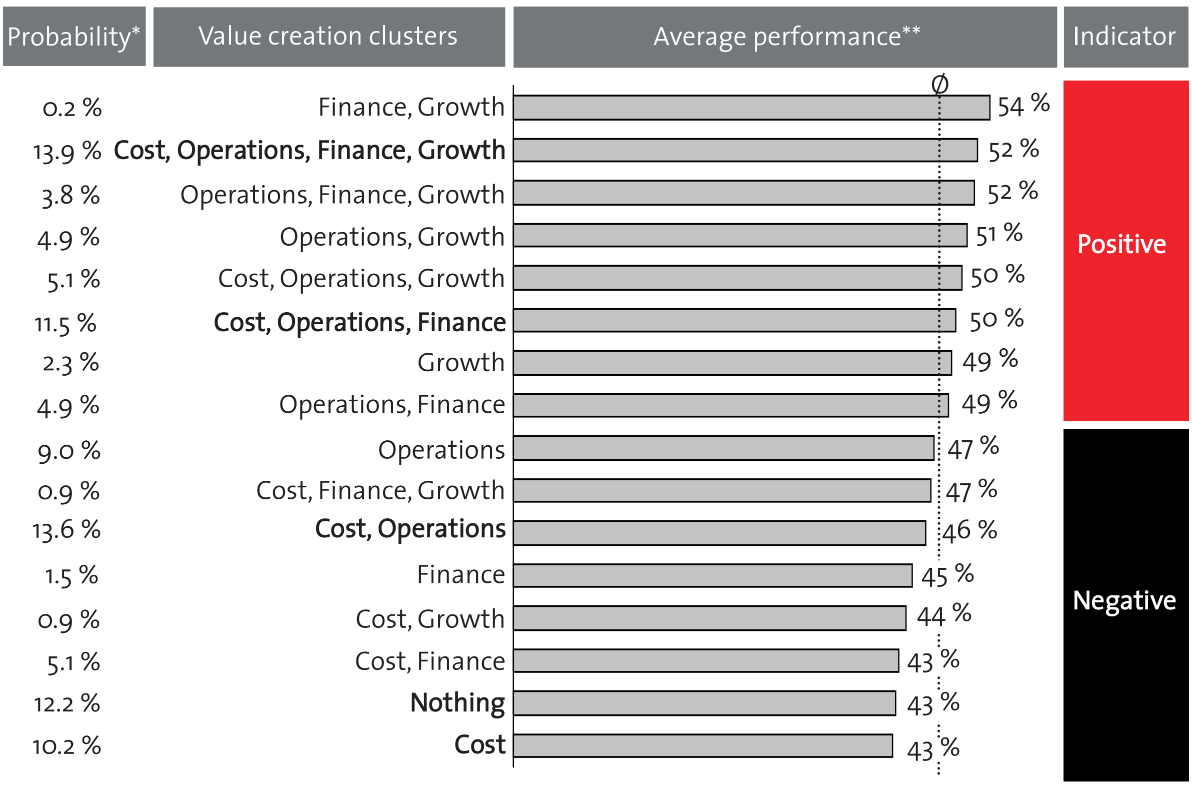
5 Supply Value Maturity Model (SVMM)

A lot of the discussion has been led by the fact whether a company is performing good or bad. Based on the SVM framework, there are four key value creation clusters how a company can generate value in procurement: cost, operations, finance and growth. The question is which value creation cluster is the best indicator for an excellent performing company.

Figure 7 displays the average performance for different value creation strategies. These strategies are clustered into four value creation cluster mentioned above (cost, operations, finance and growth). A procurement strategy is thus defined as the sum of the value creating clusters which a company perceives to be very important for its procurement. As illustrated, there are 16 different combinations like 'cost and operations' or 'cost, operations, finance and growth' possible. Figure 7 shows the average procurement performance of companies choosing a certain strategy cluster. In addition, listing the probability of the value creation clusters reveals how common a certain value creation cluster is.

From the bottom to the top of Figure 7, the average performance of a company is increasing. The graphic also shows that the better the performance, the more complex the strategy becomes as more value creation clusters are considered.

Figure 7 Strategic importance of aggregated value creation clusters.



* Percentage of participants who ticked that answer
** Performance of participants who ticked that answer

Figure 7 shows that companies with a higher procurement performance do not take completely different value creation clusters into account. The main distinction between good and bad performers is that the good performers see their strategy and their everyday work as being more complex.

There are five common combinations, each with a probability above 10%, which are marked in bold. What might be somewhat surprising is the fact that a company that is only focusing on cost as value creation target is performing similar to a company that has not defined any value creation target at all. So, cost alone cannot be the solution for a good procurement. Figure 7 also shows an interesting pattern: the more cluster a strategy contains, the better the performance. And there seems to be natural order when adding any cluster, starting with cost, then operations, then finance and finally growth.

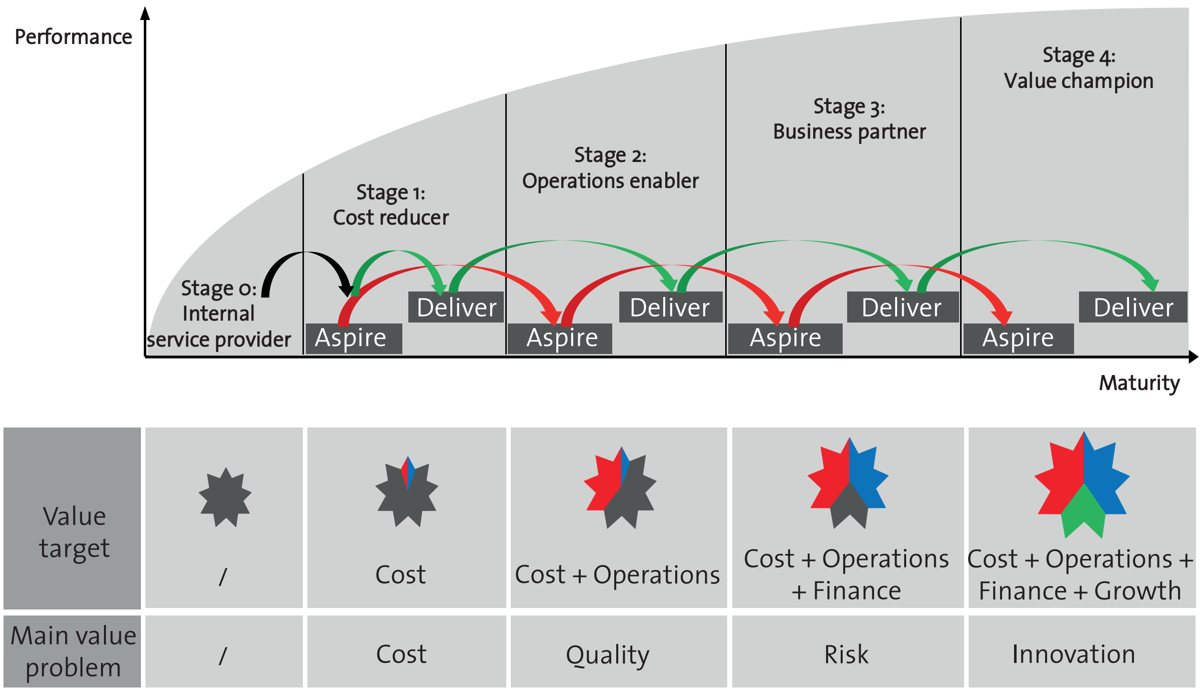
The SVMM is a framework which combines these different strategies for value creation and their related average performances. The different dimensions that are added as value creation levers form different stages a company can pass through. The SVMM shows the following five value stages with typically increasing overall performance:

0) No strategy
1) Cost focus
2) Cost & operations focus
3) Cost, operations & finance focus
4) Cost, operations, finance & growth focus.

However, stating that there is a specific value creation strategy in a company is not necessarily reflecting whether a company is also able to achieve the value creation targets that have been put in place. Therefore, the value creation strategies have to distinguish aspired and delivered value creation targets. The stages with the value targets added and the main value creation problems of each strategy are illustrated in Figure 8.

As it becomes clear from the illustration, there is a different main value problem for each of the stages. Subsequently, not all aspects of a supply value creation category are in focus once a new dimension is added to the value target. For stage 1, the main value problem is cost. In the next stage the operational perspective is added as a value cluster while the main value creation problem lies now in quality. For stage 3, the new dimension is finance and the main value creation lever most companies in this stage are struggling with is risk. In the last stage where procurement is seen as 'Value Champion', the added dimension is growth. Companies in this final stage of the Supply Value Maturity Model are mainly facing challenges in terms of innovation in order to achieve their value creation targets.

Figure 8 The five stages of the Supply Value Maturity Model (SVMM).



There is another interesting aspect of the SVM Model shown in Figure 8. Stage 0 is maybe the level where procurement has had its starting point. Based on the analysis, only 13% of companies are located at that stage (see Figure 9), so that most of the companies have already passed it by adding cost as a first value creation lever. However, there are companies who do or did deliver on this value creation target while others are or were unable to do so. Therefore, stage 1 and all following stages distinguish between aspired and delivered value creation. Comparing what companies aspire and what they are able to deliver shows that only the minority is able to deliver. Once a company proceeds from one stage to another without having been able to achieve the value creation targets of the previous stage, it is clear that company will have huge problems in delivering regarding the value creation targets of that new stage. As a consequence, a company will not be able to move directly from stage 0 to stage 5 but rather has to proceed stagewise along the maturity model.

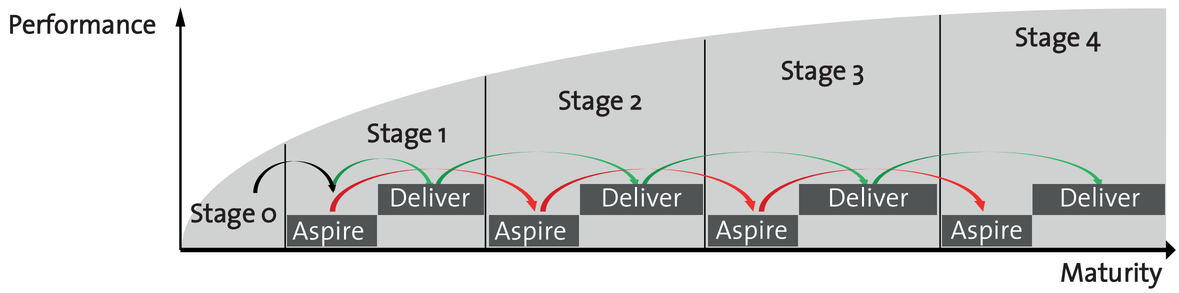
5.1 Supply Value Maturity Model for the chemical, pharmaceutical and healthcare industry

Taking a closer look at where companies in general are positioned in the Supply Value Maturity Model and where the chemical, pharmaceutical and healthcare industry in particular is situated is shown in Figure 9. Looking at the average of all companies shows that most companies are either in stage 2 with cost and operations or in stage 4 with cost, operations, finance and growth as value creation targets.

The illustration also shows that not all value creation levers of a specific value creation category are added once another cluster added. In case of adding finance, typically only risk is added as a value creation lever to the already targeted levers.

Comparing the distribution of the chemical, pharmaceutical and healthcare industry to the dif-

Figure 9 Proportion of chemical, pharmaceutical and healthcare companies in the five stages of the SVM Model.



Percentage (all industries)	13 %	14 %	3 %	14 %	9 %	10 %	7 %	15 %	15 %
Percentage (chemical, pharmaceutical and healthcare industry)	10 %	17 %	2 %	14 %	8 %	5 %	12 %	24 %	8 %
Value target	/	Cost		Cost + Operations		Cost + Operations + Finance		Cost + Operations + Finance + Growth	
Value target levers	/	Cost		Quality, Cost, Reliability		Risk, Quality, Cost, Reliability		Quality, Innovation, Reliability, Cost, Sustainabilty, Risk, Speed	
Delivered value levers	/	/	Cost	/	Cost, Quality, Reliability	/	Quality, Cost, Reliability, Risk	/	Quality, Cost, Reliability, Speed, Risk, Innovation, Sustainability
Main value problem	/	Cost		Quality		Risk		Innovation	
Delivered infrastructure levers	/	/	Controlling, Process	/	Controlling, Process, Strategy	/	Controlling, Process, Strategy	/	Controlling, Process, Strategy
Main infrastructure problem	Standing	Standing	Employees	Standing	Employees	Standing	Employees	Standing	Employees

ferent stages of the SVM Model shows that the companies are almost spread in the same way as the cross-industry sample. The analysis also shows that the main differences can be found in stages 3 and 4. Here, the aspired value creation of procurement is quite high but the procurement departments of the chemical, pharmaceutical and healthcare industry are not able deliver highly on the expected value creation.

Taking the SVM Model step by step starting with stage 0 shows that only 10% of the companies from this industry are still in the earliest stage. At this stage, procurement is seen as an internal service provider and its value contribution is very limited. In stage 1, which is focusing only on cost as a value creation lever, there are 19% of the companies in total. Although cost as the main value creation lever is not that sophisticated, only 2% of the companies from the chemical, pharmaceutical and healthcare industry are able to deliver the aspired value creation target, so that the effective value creation of companies in stage 0 and 1 is very similar.

A little more companies are located in stage 2 where the focus of value creation additionally lies on the value creation levers quality and reliability. In this stage, 8% of a total of 22% of the companies are able to deliver on the value creation target. In stage 3, with risk as additional value creation target, are most of the achievers. 12% of the companies are able to deliver the aspired value creation. The main value creation problem is that companies of the chemical, pharmaceutical and healthcare industry are not able to deliver the aspired value creation for risk. This is again underlining the fact that the industry is having a major problem with this value creation lever as already elaborated before.

Finally, there is stage 4 where most of the companies do find themselves in. Almost one third (32%) of the companies states that according to their strategy they are at this maturity stage. However, only 8% of the companies are able to really deliver the aspired value from a procurement perspective. In other words, only 8% of the companies in this industry are really 'value champions' – for the average cross-industry sample, this number increases to 15%. The main problem in stage 4 is innovation (and to a lesser extent sustainability) which is added to the (sometimes still unsolved) value creation problem of stage 3. The companies try to increase procurement's value creation by sourcing innovate products or technologies from their supplier but miss to exploit the power for growth opportunities from existing and potential new suppliers. This fact has its root cause in the Supply Infrastructure Management where procurement is struggling with achieving the necessary standing for having the necessary power to drive value creation.

In total, the number of 'Value Champions', i.e. those companies who are able to deliver on all value creation clusters in stage 4, is quite low. But at the same time, the aspired value creation of procurement in the chemical, pharmaceutical and healthcare industry is quite high. That way, most companies are not able to deliver the aspired value creation targets. This is already based on the results derived by analyzing the Supply Value Management and Supply Infrastructure Management where risk management and the standing of procurement have already been outlined as major bottlenecks.

6 Conclusion

There are three frameworks for procurement provided in this article. First, there is Supply Value Management that is clearly defining which value creation levers procurement really has. It is a framework that helps any company to choose what is really important for procurement in a specific industry and company e.g. to decide which suppliers to choose.

In addition to this framework, there is Supply Infrastructure Management, which is combining all relevant supporting aspects for value creation by the SVM. Its seven aspects are supporting the nine value creation levers and are not value creating by themselves. The SIM answers which resources are needed to create value with procurement.

Finally, there is the Supply Value Maturity Model. This framework allows to allocate a company regarding its procurement maturity to five potential stages. From stage 0 where procurement is seen as an internal service provider to stage 4 where procurement is value champion delivering on the cost, operations, finance and growth value creation clusters. Each of the stages additionally distinguishes whether a company only aspires or really delivers on the value creation clusters.

A close look at the Supply Value Management framework for the chemical, pharmaceutical and healthcare industry revealed major value creation potentials in the field of cost, risk and quality. In comparison to all industries, it becomes obvious that the performance for all value creation levers is significantly lower. For most companies in this industry, it would therefore be a good advice to improve on risk, quality and cost to achieve a better value contribution of procurement.

The main reason why companies are struggling with achieving higher value creation resulting in a better procurement performance can be found in the Supply Infrastructure Management. As mentioned, the chemical, pharmaceutical and healthcare industry has to improve on all aspects of the

SIM. The activities to improve SIM are concerning a better connection to the executive management and increasing the standing of procurement within the company. Before doing so, an improved controlling with more transparency of procurement's value contribution should be implemented.

Most of the companies of the chemical, pharmaceutical and healthcare industry are to be found in stage 2 and stage 4 of the Supply Value Maturity Model, meaning they focus to a minimum on cost and operational aspects. However, the differences for the aspired and delivered value creation in the SVM Model are highest in stages 3 and 4. From a value creation perspective, the major problem has to been seen in the field of risk while from an infrastructure perspective, the main problem is the standing of procurement within the company.

The chemical, pharmaceutical and healthcare industry is an industry with high aspirations regarding procurement but only average performance, which has its root cause in a too low standing of procurement by senior executives, leading to a situation where procurement has huge problems to deliver on advanced procurement value creation levers like risk and innovation management of suppliers.

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Practitioner's Section

Chemical industry activity as a leading indicator of the business cycle

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Activity in the chemical industry has been found to lead that in the overall economy. The author constructs a Chemical Activity Barometer (CAB) that is a leading indicator which can be used to anticipate the peaks and troughs in the US economy's business cycle. This article discusses the construction of the CAB and its performance. The results were robust and since 1919, the CAB was found to lead National Bureau of Economic Research (NBER) business cycle peaks by an average of eight months and troughs by an average of four months. In this time of such uncertainty, the CAB could be an important tool for economists, business analysts and anyone else trying to follow the US economy.

1 Introduction

In the study of economic fluctuations, many industries have been found to lead or lag the overall business cycle. When an industry (or some of its products) consistently leads the economy's business cycle, a leading indicator or barometer can be developed from measures of that industry's activity. The indicator can be used to assess turning points in the economy's business cycle. These turning points are the business cycle peaks and troughs that the National Bureau of Economic Research (NBER) uses to identify the economy's recessions and expansions or downturns and upturns. Activity in the chemical industry has been found to lead that in the overall economy. This paper provides an overview of a Chemical Activity Barometer (CAB) that is a leading indicator which can be used to anticipate the peaks and troughs in the US economy's business cycle.

2 Business Cycle Indicators

The development of leading economic indicators of the business cycles has a long and interesting history. Business cycle indicators have proven to be useful tools for analyzing alternating sequences of economic expansions and contractions known as the business cycle (Persons, 1922; Wallace, 1927; Moore, 1980; and Moore 1990).

Business cycle indicators are based on business cycle theory that focuses on generally uniform sequences in economic activity noted by Wesley C. Mitchell (Mitchell, 1927). These sequences are revealed in statistical time series indicators that typically lead, coincide, or lag the business cycle. In its modern form, the approach can be traced to a list of business cycle indicators compiled by Wesley C. Mitchell (Mitchell, 1927) and then Wesley C. Mitchell and Arthur F. Burns for the NBER in the 1930s (Mitchell and Burns, 1938) and later refined in the 1940s (Burns and Mitchell, 1946). Indeed, much of the early research of the NBER focuses on developing a system of indicators to anticipate cyclical change in the economy as well as development of national income concepts and measurements. Geoffrey H. Moore built upon the research of Burns and Mitchell to develop the original index of leading economic indicators (LEI) for the United States (Moore, 1980). Thereafter, the business cycle indicator approach was further developed and refined. In 1961, the US Department of Commerce began publishing *Business Cycle Developments*, a monthly review of cyclical indicators identified by the NBER. The publication was renamed the *Business Conditions Digest* in 1968 and subsequently rolled into the *Survey of Current Business* (Niemira and Klein, 1994) that is still published by the Bureau of Economic Analysis (BEA). In 1995, this BEA cyclical indicators program was transferred to the Conference Board, a business membership and research association.

In order to emphasize the cyclical patterns inherent in the various individual cyclical indicators and de-emphasize the volatility of the individual indicators, the best of them are combined into composite indexes. Composite economic indexes can be leading, coincident, and lagging. They are essentially composite averages of several individual leading, coincident, or lagging indicators. They are constructed to summarize and reveal turning point patterns in economic data in a clear and convincing manner than any individual components as they smooth out some of the volatility of individual components (Burns, 1950; Zarnowitz, 1992). Use of these composite indexes is consistent with the historical view of the business cycle developed by Burns and Mitchell (1946). In particular, composite indexes can reveal common turning point patterns common to a number of cyclical indicators in a clearer and more convincing manner than the behavior of any individual indicators. Essential to understanding the business cycle is the ability to distinguish between leading, coincident and lagging indicators of the cycle, which essentially reflects the timing of their movements:

- Leading indicators (average weekly hours, new orders, consumer expectations, building permits, stock prices, etc.) are those that consistently turn before the economy does.

- Coincident indicators (employment, industrial production, personal income, business sales, etc.) turn in step with the economy and track the progress of the business cycle.

- Lagging indicators (inventory-to-sales ratios, change in unit labor costs, C&I loans outstanding, etc.) turn after the economy turns, thus playing a confirming role.

These three types of indicators are important in their own right although most attention is focused on the leading indicators because they tend to shift direction in advance of the business cycle. Leading indicators are better at calling the direction of the economy (contraction or expansion) than in predicting the pace of growth. This is based on economic theory first explained six decades ago at the NBER by Ruth Mack in her landmark study of the shoe, leather and hide industries (Mack, 1956). Although the use of composite economic indexes has existed for nearly three-quarters of a century, their use has been eclipsed by the more widespread use of structural econometric and times series analysis techniques. Nonetheless, composite economic indexes are still used by business economists and other analysts. Currently, the most prominent US composite economic indicators are those reported by the Conference Board, the Economic Cycle Research Institute (ECRI), and the Organization for Economic Co-operation and Development (OECD).

3 Constructing a Chemical Activity Barometer (CAB)

It makes sense that a composite index of chemical industry activity leads activity in the overall economy because the sector is affected first by underlying changes in the economic environment and its dynamics are determined partly by their position in the value chain. Since the chemical industry is a supplier to many other industries in the economy, it is highly vulnerable to inventory effects. These effects can occur if customers of chemicals place fewer orders in order to run down their own inventories. As a result, chemicals production tends to reveal cyclical developments at an earlier stage than other industries.

3.1 Various chemicals and plastic resins lead the cycle

The CAB is a composite economic index designed to be a leading indicator of broader economy-wide activity. Each component has a lead time that helps determine the direction in which the economy is heading.

To analyze these leading properties of chemical production, the author examines the relationship between the cycles in the production of the selected chemicals in Table 1 (and other chemicals) and business cycles in the larger economy. The focus is set on the period from 1947 to 2012. As discussed above, many chemicals (and chemicals-related indicators) have features (or properties) that by their position in the supply chain lead the overall business cycle. For example, chlorine is an inorganic chemical product used as raw material starting block for polyvinyl chloride (PVC) resins. These PVC resins are used to manufacture a wide variety of plastic products for building and construction (siding, pipe, windows and doors, etc.), consumer and institutional, packaging, electrical/electronic OEM equipment (i.e., wire and cable) and other applications. Thus, production of PVC resins (and chlorine) could normally lead plastic products production, which in turn should lead home construction and production of a broad class of goods manufacturing. Activity in the chemical industry, which mainly produces intermediate goods sold to other manufacturing industries, correlates most closely with activity in the manufacturing cycle. The chemical industry is an early-cycle industry as it exhibits its turning points in the business cycle earlier than the overall manufacturing industry and the overall

Table 1 Average leads of selected chemicals compared to recent business cycles peaks and troughs.*

Chemical	Average lead at peaks (months)	Average leads at troughs (months)
Chlorine	8	2
Caustic soda	7	2
Soda ash	4	2
Titanium dioxide	4	3
Polyethylene	5	5
Polypropylene	6	7
Polyvinyl chloride	8	4
Styrene-based latexes	8	4

*Based on the period 1947-2014 where data are available (Sources: American Chemistry Council, Census Bureau, US Bureau of Mines/US Geological Survey, NBER).

economy. This also holds true for plastic and rubber products, the chemical industry's prime end-use customer industry. For recent business cycles, Table 1 presents the average lead (in months) in the production of a number of chemicals compared to NBER business cycle peaks and troughs. The data represent averages as the variance of leads for any one chemical individually can be large. In PVC resins, for example, leads at peaks were as short as two months or as long as 17 months. In some cases, no lead was provided (PVC in the 1991 trough) or even lagged the overall business cycle (by one month at the 1991 trough for chlorine). Despite just-in-time inventory management, the average leads did not appreciably change during this six decade period.

3.2 Theory behind developing a composite index

The results of this investigation of data (and leads and lags) were eventually used to develop a leading economic index (or barometer), the CAB. The performance of single indicators in any given period is likely to vary due to which causal forces are dominant. Some leading indicators may perform better in some conditions and other indicators in differing conditions. Individual times series, for example vary in timing and smoothness. No single leading indicator of an economic process or leading indicator system based on a product is perfect and some measure of protection against changes in leads and lags, and surprises of individual cases is needed. This can be accomplished by combining several leading indicators into one leading composite series (Burns, 1961). To improve the chances of getting true signals and reduce those of getting false signals, economists rely on a broad group of leading indicators and combine these into an appropriately constructed composite index (Zarnowitz, 1992). Due to diversification of many indicators, a composite index of leading indicators should work better over time than single indicators. Even with this methodology, a composite indicator can still engender false signals. Decision rules need to be developed in order to screen the information and determine cycle turning points signaled by a composite leading index. In addition, there need to be periodic reviews of the cyclical indicators used to construct the composite leading index to ensure the indicators still lead and are representative of the economic process and its place in the supply chains as well as add or substitute new indicators to the composite (Niemira and Klein, 1994).

Understanding the role of the chemical industry in the manufacturing industry and in the overall economy provides the foundation for developing a leading barometer of the business cycle using data on chemical production and other chemicals-related indicators. Useful leading economic indicators (or barometers) reflect economic relevance, they can be collected and processed in a statistically acceptable manner, they are fresh and not subject to frequent revision, they do not fluctuate erratically from month to month, they move reliably with general business activity, and they exhibit a consistent pattern over time as a leading indicator. By combining a number of indicators to create one composite barometer, the Chemicals Activity Barometer (CAB), addresses these criterion.

3.3 Constructing the CAB

To construct the CAB, a number of chemicals (and chemicals-related indicators) are evaluated. Theindicators finally included in the composite encompass a weighted average of the production of chlorine and other alkalis, titanium dioxide and other pigments, PVC and other plastic resins (i.e., a mix of chemical products production); chemical prices; hours worked in chemicals; chemical company stock prices; end-use (or customer) industry sales-to-inventories; and several broader economic leading economic measures (building permits and Purchasing Managers' Index of the Institut for Supply Management (ISM PMI)). High frequency data such as chemical railcar loadings, prices, and equity prices are used to extend the CAB for the current month.

Some challenges posed in developing the CAB include issues with consistency in the underlying time series over the time period. For example, the transition from the SIC to the NAICS nomenclature presents consistency challenges. In some cases, monthly production data are not available for the entire period and an industrial production (IP) index that measured the approximate activity is chain-indexed and employed to extend the data. In other cases, alternative measures are employed such as chain-indexing to expand a time series. For example, the S&P index for chemicals only goes back to January 1990. Its composition differs from that of another index used from January 1946 through December 2001. The latter, for example, is chained with the newer index to create one continuous index (or times series). Similar procedures are employed in dealing with production data.

There is a distinct break in the data used in constructing the CAB in the period prior to 1946. The production-oriented data simply changed through time due to reporting changes in government and trade association statistical programs. Some of the physical production data (e.g., chlorine) are available back to the opening months of World War II but there was generally a paucity of data. In addition, many of these products went through different stages of the product life cycle. A plastic resin such as low density polyethylene, for example, would have been considered a specialty, high-performance product in the 1940s but by the 1960s would have been considered a commodity.

An older monthly Federal Reserve Board chemicals production index (with a base year of 1935-39 average = 100) is available back to 1923 and monthly data are available for other products (e.g., wood alcohol or methanol) and used to create production indexes to represent chemical industry output back to 1918. Along with consistent price and other data this is used to extend (via chain-indexing) the CAB back to 1918. The collecting of data provides unique insight into the changing structure and composition of industry.

Using the times series data discussed above, the CAB is constructed using a five-step procedure similar to that used by the Conference Board's to calculate composite indexes. This is a non-model approach and the steps are:

1) Calculate month-to-month changes in the component indices;

2) Adjust month-to-month changes by multiplying them by the component's weighting;

3) Sum the adjusted month-to-month changes (across the components for each month);

4) Compute preliminary levels of the composite index; and

5) Rebase the composite index to reflect the average lead (in months) of an average 100 in the base year (the year 2007 was used) of a reference time series (the Federal Reserve's Industrial Production index was used[1]).

To update the CAB from month to month, steps 1 through 4 are followed to incorporate the most recent six months of data. The revisions to the base year (step 5) are made when the Federal Reserve changes its base year for the industrial production (IP) index.

To determine business cycle peaks and troughs, the NBER examines and compares the behavior of various measures of broad activity: real GDP measured on the product and income sides, economy-wide employment, and real personal income. The NBER also may consider indicators that do not cover the entire economy, such as real business sales and the Federal Reserve's index of industrial production (IP). For the purposes of this analysis, the industrial production index was used as a reference time series due to its long history and consistency.

Analysis of the data indicates a positive correlation of over 0.90 between the industrial production index and the CAB eight months prior. There is also a high correlation between real business sales and the CAB. More interesting is how the average leads have changed through time.

1) The Federal Reserve Board's headline industrial production index was used as a reference time series due to its consistent coverage back to 1919.

Table 2 presents the timing relationship (in terms of months of lead) between the CAB and the overall business cycles since 1919. The findings should be viewed in perspective, insofar as not every cycle in industry proceeds uniformly. When comparing the chemical industry and overall business cycles, the respective intervals of the turning points can vary substantially. The data presented in Table 2 indicate that the chemical industry's lead time can vary. The CAB provides a longer lead (or performs better) at business cycle peaks, leading by two to 14 months, with an average lead of eight months. The median lead was also eight months. At business cycle troughs, the CAB leads by one to seven months, with an average lead of four months. The median lead was also four months. In the most recent business cycle, the CAB led the peak by five months and led the trough by three months.

Examining the data in Table 2, the author divided the 1918-2014 period into 3 roughly three-decade periods to examine how the average leads changed. The first period represents a period that was characterized by two world wars and the Great Depression and one in which data availability was scarce. The second period from 1947-1973 reflected a period in which US data quality improved and was broadened and one in which was characterized by the Post World War II boom. The years 1973 was chosen as it represented the first oil price shock and the end to the boom. The period from 1973 represented a period characterized by several oil price shocks, the Great Moderation, and lastly the financial crisis and the Great Recession. The data indicate that there was little difference between the first and second periods in terms of average leads at peaks and troughs. There was, however, a dis-

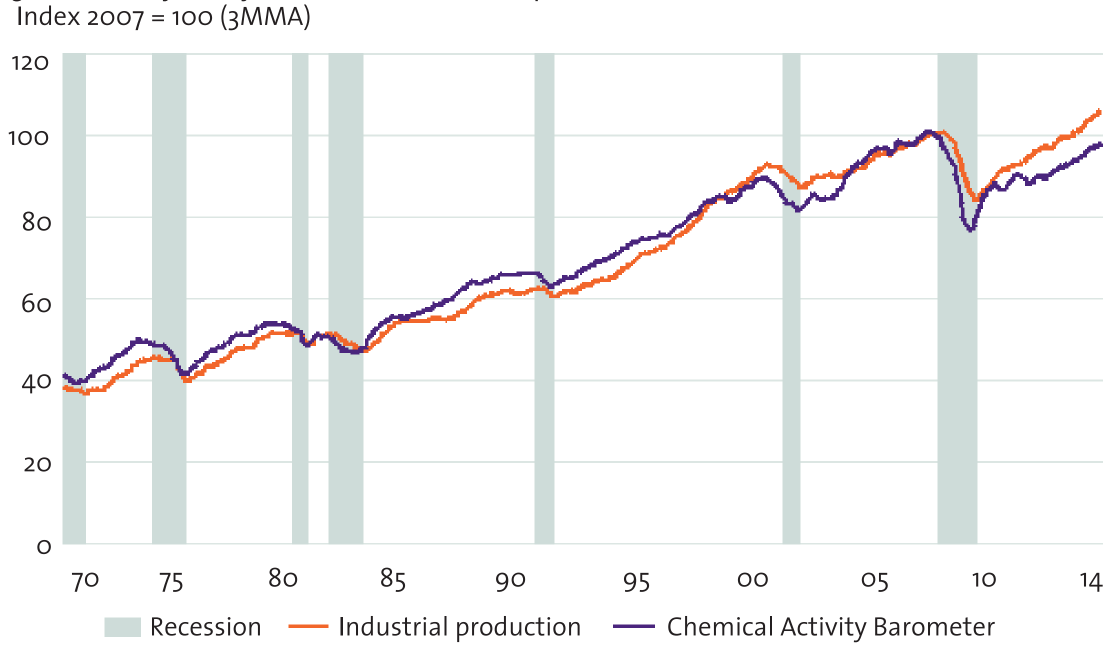
Table 2 Leads - Chemicals Activity Barometer (CAB) versus NBER business cycle peaks and troughs.

NBER business cycle		Chemicals Activity Barometer		Timing relationship (months)	
Peak	Trough	Peak	Trough	Peak	Trough
August 1918	March 1919	January 1918	February 1919	7	1
January 1920	July 1921	Ocotber 1919	May 1921	3	2
May 1923	July 1924	December 1922	November 1923	5	8
October 1926	November 1927	June 1926	December 1926	4	11
August 1929	March 1933	December 1928	July 1932	8	8
May 1937	June 1938	December 1936	April 1938	5	2
February 1945	Ocotober 1945	August 1943	September 1945	18	1
November 1948	October 1949	September 1948	July 1947	2	3
July 1953	May 1954	May 1953	January 1954	2	4
August 1957	April 1958	December 1956	March 1958	8	1
April 1960	February 1961	May 1959	October 1960	11	4
December 1969	November 1970	February 1969	April 1970	10	7
November 1973	March 1975	February 1973	February 1975	9	1
January 1980	July 1980	November 1978	May 1980	14	2
July 1981	November 1982	November 1980	June 1982	8	5
July 1990	March 1991	March 1990	December 2000	4	3
March 2001	November 2001	April 2000	October 2001	11	1
December 2007	June 2009	July 2007	March 2009	5	5
			Average	**8**	**4**
1918-1947				7	5
1947-1973				7	5
1973-2014				10	2

Sources: American Chemistry Council, NBER tinct change with the third period. In the third period, the average lead at peaks improved, from seven months to 10 months. At the same time, the average lead at troughs deteriorated, from five months to two months.

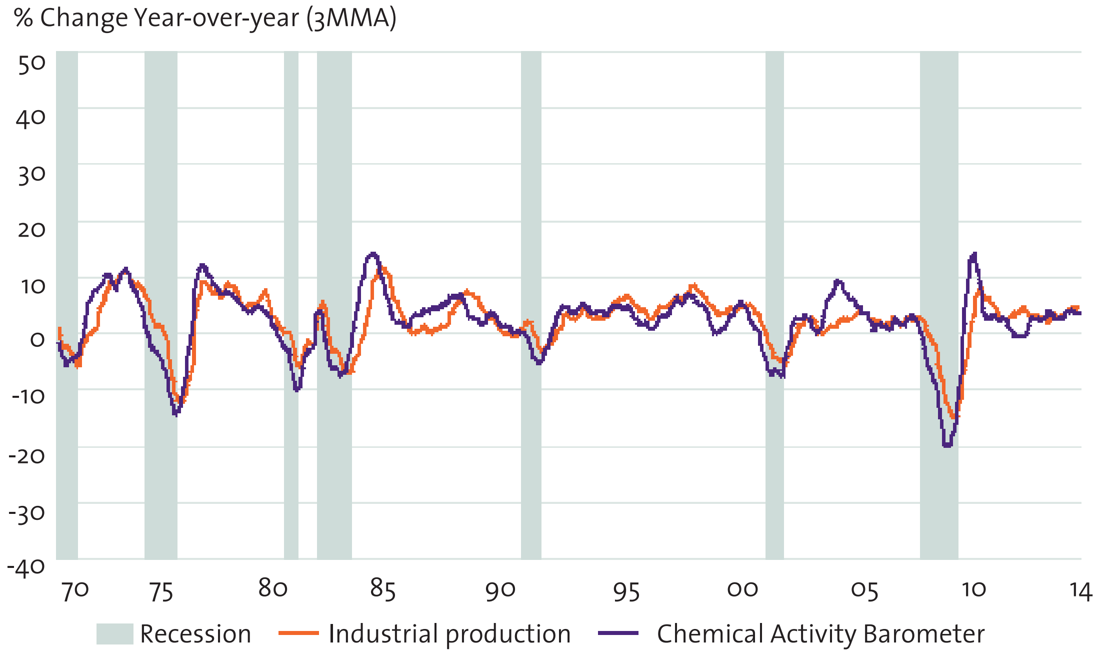
The CAB is not a leading index of chemical industry activity. Rather, it is a leading index (barometer) based on chemical industry data that leads overall industrial production and the overall business cycle. The relationship between the CAB and IP index are presented in Figures 1 and 2. Figure 1 presents the CAB versus the IP index and Figure 2 presents the year-over-year growth rate of the CAB and the IP index for the 1948 through 2014 period.

Figure 1 Chemistry Activity Barometer versus industrial production index.



Sources: Federal Reserve Board, Author's calculation

Figure 2 Year-over-year change in Chemistry Activity Barometer and industrial production index.



Sources: Federal Reserve Board, Author's calculation

The data for both are available back to 1919. The shaded columns in both charts represent periods of recessions. The data presented in both figures are based on three-month-moving averages to smooth volatility and thus ease comparisons.

The predictive value of the CAB or other leading indicators is limited by the weight assigned to its component indicators to distill information in each into a single variable, and the varying degree of efficacy of those indicators over differing time horizons. As a result, leading indicators can sometimes provide false signals indicating early peaks (or early troughs). This is especially the case with a composite indexes based on a limited number of underlying indicators, some of which are correlated. A decision rule is needed. For purposes of this analysis, a false signal is defined as periods where the indicator declines for three or more consecutive months and that the decline in the leading indicator (in this case the CAB) exceeds 3% from peak to trough but that an official recession (as per NBER) does not occur. As Figure 2 illustrates, the early supply chain position of the chemical industry makes it vulnerable to wide swings of production activity. This is especially the case with individual products; a main reason why a composite index of activity is used. Swings of ±10% are not unusual and the criteria suggested above represent a low bar. Using this decision rule and examining the CAB performance, however, a false peak has only occurred once (in March 1966 when a false peak occurred in connection with a "growth recession" at that time). At other times (March 1984, June 2002, April 2006, April 2010, and March 2011) slowing activity was signaled with three or more consecutive months of slight to modest decline. Even less pronounced were several two-month slowdowns flagged in July 1951, December 1955, and January 1995. When taking a higher percentage limit for decline, no false signals emerge.

The CAB estimate for any given month can be released by the fourth week of that month as sufficient high-frequency data are available for that month. The monthly CAB estimate is subject to revision (reflecting revisions in the underlying data). This is particularly the case of the CAB released during the current month using high-frequency data. But because of the nature of the underlying price, equity and production data, non-benchmark monthly revisions are generally minor once the current month CAB reading is revised during the subsequent month.

4 Summary

Due to the chemical industry's early position in the supply chain, the CAB is useful in determining future trends in the overall business cycle and the overall US economy. The CAB is particularly useful in indicating business cycle peaks and in signaling the phase of the business cycle in which the economy is heading. The CAB is a valuable tool that can be used by business journalists, business economists, policy advisors, security analysts, and others interested in assessing the future direction of the US economy.

This approach could be extended to the EU and other nations and regions but due to the paucity of data, the time period would be shorter. For the EU28, for example, quality consistent data may only be available back to 1990. That said, the approach could be applied to nations such as Canada and the United Kingdom that do have extensive indicator data for a long time period.

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