Critical reflections on the chemical leasing concept

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Abstract
Chemistry has been recognised as an important discipline for contributing to the design and implementation of sustainable development strategies. Green chemistry and sustainable chemistry have appeared as concepts to frame such strategies. They involve a reduction and eventual elimination of hazardous substances. Within this context chemical leasing has been recently developed as an alternative business model to help use chemicals more efficiently and reduce waste and closing feedback loop more effectively. The chemical leasing model is based on chemicals not purely being sold for profit by high volume of sales, instead it offers financial incentives for both the supplier and the user of the chemicals to improve efficiency and reduce the volumes of chemicals required in a process and reduce their environmental impact. Nonetheless, current studies on the topic have been mainly empirical and descriptive, with limited theoretical work on the topic. This paper provides a critical discussion on the chemical leasing model/concept terminology by focusing on green and sustainable chemistry, business models, collaboration, and the chemical leasing cases available. The discussions show that chemical leasing can be a more efficient business model alternative to traditional industry practice, bringing economic and environmental benefits to suppliers and users, but its use is restricted to some specific types of chemicals (such as solvents and catalysts). The paper proposes a clearer definition of chemical leasing. It also argues that chemical leasing needs to be complemented with other approaches to better address the social and time dimensions.

Keywords: Chemical Leasing; Green Chemistry; Sustainable Chemistry; Sustainability Business Model

1. Introduction

> "to an amount not usually recognised, chemicals are part of our everyday life" (Perthen-Palmisano & Jakl, 2005, p. 49)

The importance of the chemical industry goes back to the XVIII century, when the manufacture of sulphuric acid, alkalis, and the need for textile bleaching sparked the industry's growth. This set the basis for chemistry as a science in the early part XIX century and promoted the rapid expansion of chemical manufacturing that occurred in the century's second half, and finally the explosion of innovations that happened during the XX century, which made the chemical industry highly relevant for today's societies (Aftalion, 2001). The production of chemicals have been thoroughly linked with economic growth, quoting Arora et al. (1998) "*… the ability to draw upon science and technology also depends on the performance of the institutions of learning, on the scientific and engineering research conducted by various public and other institutions, and on whether the broader social climate looks favorably upon science*". This has resulted in a complex network of chemical industries that has involved several stakeholders mainly based on the economic return of marketing and selling chemicals.

The global chemical industry was worth around US$1,500 billion (1.5 trillion) in sales in 1998 and employed around 10 million people globally (OECD, 2001). By 2010, the global chemical industry – excluding pharmaceuticals - was worth $3.2 trillion in global chemical sales, the top 100 companies generating an estimated $1.23 trillion of those sales (Hartnell, 2011), and by 2015 it is estimated that the global chemical market will be worth 4,160 billion (4.16 trillion) US dollars (Meyer, 2011).

In the 1990s, the majority of chemical sales were to developed countries, with 85 per cent of the world's chemicals being consumed by industrialized countries, despite those countries only supporting 24 per cent of global population (Redclift & Sage, 1994). Cefic (ECIC, 2012) provides a detailed set of statistics about the chemical industry, its key findings including that: Asia accounted for 33 per cent of world exports and 37 per cent of world imports in 2010 (compared to 44 per cent and 37 per cent respectively for the EU-27); sales by the EU-27 member states fell from 29.2 per cent of the global total in 2000 to 20.9 per cent in 2010 (the European Union moving from first to second place in terms of world sales); twelve of the 30 major chemical-producing countries were Asian (five of the top ten were China, Japan, Korean Republic, India and Taiwan); emerging economies in the Asia-Pacific and Latin American regions outpaced industrial countries in both the EU-27 and NAFTA regions (including growth in the production of pharmaceuticals), much of the growth in the Asia-Pacific being accounted for by booming economic growth in China; Chinese sales increased from 6.4 to 24.4 per cent of the global total (moving from fifth to first) and the Rest of Asia (excluding Japan) saw increased sales from 14.6 to 17.8 per cent (moving from third to fourth); China became the biggest chemicals producer in 2010 (the top five being completed by the US, Japan, Germany and France in that order).

Chemicals are used to make almost all man-made products, including many which can be used to protect crops and increase yield, prevent or cure disease, and provide many benefits to improve people's daily lives. The OECD (2001) identifies the main chemical types as basic (or commodity) chemicals, specialist chemicals that are derived from those basic chemicals, products derived from life sciences (including pharmaceuticals and pesticides), and consumer care products (including soaps and detergents). The general structure of the chemical industry, including those chemical types and consumers of those chemicals, is outlined in Figure 1.

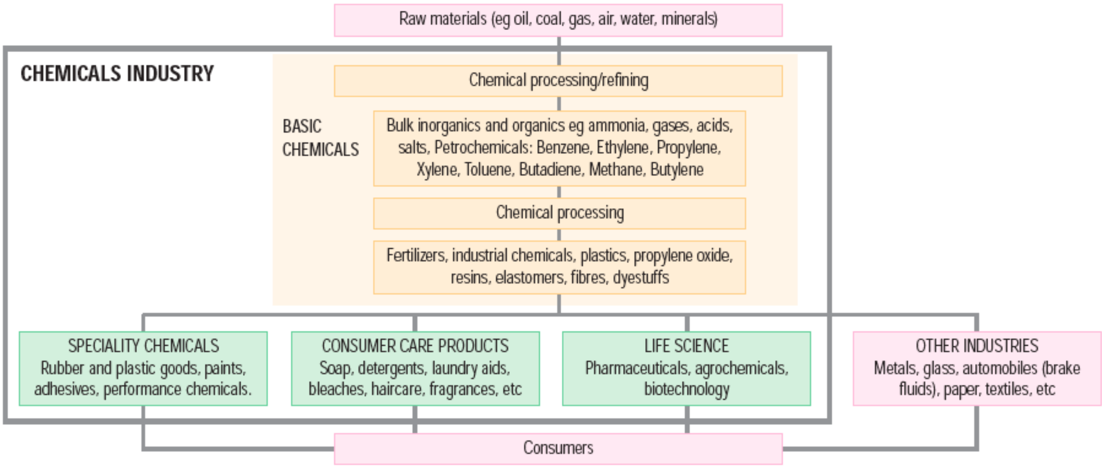

Figure 1 - The general structure of the chemical industry
Source: (OECD, 2001)

Another way of classifying chemicals is by their type, which includes: inorganic industrial, organic industrial, ceramic products, petrochemicals, agrochemicals, polymers, elastomers, oleochemical, explosives, and fragrances and flavours. Chemicals can also be classified into: reactants (e.g. acids and bases) and non-reactants (e.g. solvents and catalysts).

The chemical industry has been highly innovative. The centennial anniversary of the American Institute of Chemical Engineers lists 100 market innovations related to chemicals mainly by USA companies (Chemical Engineering Progress, 2008) and celebrated the innovation and importance that is representative of the profession. According to Miller (2002), every year, 1,000 new synthetic chemicals enter the market, adding to the approximately 75,000 chemicals already commercially available. Of those 75,000+ chemicals, only around 10 per cent have undergone testing for toxicity and 2 per cent to determine if they are carcinogenic, teratogenic or mutagenic.

While there are many benefits from the use of chemicals, they can also pose serious risks to both human health and the environment, for instance the production, use and release into the atmosphere of chlorofluorocarbons, and their inherent stratospheric ozone depletion, discovered decades later; or the use of the anti-knocking tetraethyl lead, mixed with gasoline employed in internal combustion engines, which was later found to be toxic. The health risks from the use of chemicals have long been recognized. Feitshans (1989) noted that the first evidence of risk from acute or chronic exposure to benzene, an industrial solvent primarily used for degreasing metal, was identified in the US in 1897. In the case of dyes manufactured using chromium, Hayes (1988) identified cases of lung cancer which were observed in workers in a number of countries including Scotland and Germany, and as early as 1911. In a study examining the link between exposure to chemicals and the risk of cancer occurring in humans, using data from the years 1971 to 1978, Tomatis et al. (1978) identified 26 chemicals where industrial processes were linked with cancer (18 of which were identified as being from occupational exposure, the remainder from medical exposure) and identifies a further 221 chemicals where there was some evidence that they were carcinogenic (see Tomatis et al., 1978). More recently, Tolbert et al. (1992), highlighted the number of machining fluids (coolants and lubricants) used in machining operations by the United States of America (USA) automotive industry, and identified a range of substances suspected of promoting cancers.

Awareness of the toxic effect of chemicals on the environment has been less well understood than their health risks and did not really come to the forefront of public awareness until the publication, in 1962, of ‘Silent Spring’, the seminal work by Rachel

Carson (2000). In her book, Carson highlighted the dangers arising from the use, by the US government, of chemicals including DDT as a pesticide for agriculture, forestry and to combat diseases such as malaria, through the eradication of insect vectors. Carson's book also resulted in a better understanding of the inter-connectedness of the environment, the economy and society (three of the four dimensions of sustainability described by Lozano (2008b), the missing fourth dimension being the time).

A number of international initiatives have been undertaken since the turn of this century to achieve the safe management of chemicals. At a global level, the UN adopted the Globally Harmonized System of Classification and Labelling of Chemicals (GHS)[1] at the US Economic and Social Council in July 2003 to address the classification of chemicals by type of hazard (physical, health and environmental) and to harmonize the communication of those hazards through a consistent system of labelling and the provision of data sheets (see UNECE, undated). At a regional level, the EU, in 2006, introduced a Regulation on Registration, Evaluation and Authorisation of Chemicals (REACH) (European Commission, 2006), which is aimed at improving the protection of human health and the environment through a better understanding of the properties of chemicals and places responsibility on industry to manage the risks from those chemicals (European Commission – Environment, 2012). Similar REACH-like regulations have also been developed in China (CIRS, 2012), and actions have been taken to establish or strengthen the regulation of chemicals in Canada, the US, Japan, Taiwan, China, Turkey and Switzerland (Banerjee, 2010). For example, in the case of Japan, Banerjee (2010) notes that its Chemical Substances Control Law of 1973 was amended in May 2009 and moves from hazard- to risk-based management and development of a priority list for risk assessment.

Sound chemicals management was also one of the objectives of the Plan of Implementation from the World Summit on Sustainable Development held in Johannesburg in 2002, where 2020 was set as the deadline for the fulfilment of the requirements of that Plan (UN, 2002). In this plan it was set out that chemicals be used and produced "in ways that lead to the minimization of significant adverse effects on human health and the environment" and that developing countries be supported "in strengthening their capacity for the sound management of chemicals and hazardous wastes" (UN, 2002, p. 10). The report also indicated the need to encourage partnerships "to promote activities aimed at enhancing environmentally sound management of chemicals and hazardous wastes" including the collection and use of scientific data. Aimed at supporting countries in achieving the objective of sound chemical management from Johannesburg, a Strategic Approach for International Chemicals Management (SAICM) policy framework was adopted at the International Conference on Chemicals Management held in Dubai in 2006 (UNEP, 2006). On that occasion, chemical leasing was first discussed as a model for chemical management services (CMS), the latter being defined as "a business model in which a customer engages with a service provider in a strategic, long-term contract to supply and manage the customer's chemical and related services" (Stoughton & T. Votta, 2003).

Within this context and to assist businesses globally, UNIDO launched its Global Chemical Leasing Programme in 2005, with support from Austria and Germany, and with pilot projects across a wide range of industry sectors, processes, and chemicals. The sectors included car manufacturing and the textile, petrochemical and printing industries, while the range of chemicals included solvents, dyes, lubricants, glues and catalysts (UNIDO, 2011).

[1] The third revised edition of the GHS (2009 version) is available online at: http://www.unece.org/trans/danger/publi/ghs/ghs_rev03/03files_e.html

This paper is aimed at providing clarity through critical reflections to the questions posed by Satric, Carpenter, and Lozano (in press) about the limitations, scope, and reach of the ChL concept. This paper starts by providing a discussion on Green and Sustainable Chemistry, followed by a discussion on business models for sustainability. It then presents the principle of collaboration and its importance to sustainability. It continues by presenting the Chemical Leasing concept. The concept is then discussed. The conclusions offer a definition of the ChL concept.

2. Green and Sustainable Chemistry

As a response to negative environmental and social impacts of chemicals the industry has moved towards developing new products and processes to implement sustainable development strategies. Two major approaches have appeared for this: green chemistry and sustainable chemistry.

Green chemistry is the response of the chemical field to evolving global needs (Anastas & Eghbali, 2010; Anastas, Heine, & Williamson, 2000; Anastas & Kirchhoff, 2002; Anastas & Warner, 2000; Collins, 2001). Green chemistry focuses on the use of chemical techniques to reduce or eliminate the use, or generation, of feed-stocks, products, by-products, solvents, reagents, or other hazardous chemicals that are, or might be, dangerous to human health or the environment (Anastas & Breen, 1997). It is aimed at preventing waste before it is ever formed by considering the environmental impact, or potential impact, of a product or process (Anastas & Breen, 1997). For example, this may be achieved through the use of catalysts that decrease energy requirements, increase selectivity, or permit the use of less hazardous reaction conditions (Kirchhoff, 2005).

Green chemistry can aid in achieving sustainability through: (1) the development of economical and renewable energy sources; (2) the use of reagents derived from renewable materials; and (3) by replacing pollution-generating technologies with clean alternatives. Green chemistry relies on 12 rules based on five principles (waste minimisation, renewable resources, eco-efficiency, degradation, and health and safety) that are aimed at designing or modifying chemical reactions to be more environmentally friendly (Glavič & Lukman, 2007).

Often, the terms green chemistry and sustainable chemistry are used interchangeably (Tundo et al., 2000). However, they are inherently different. While the goal of green chemistry is to advance sustainability (Anastas & Eghbali, 2010), some authors propose that green chemistry under-emphasises the social dimension of sustainability (Böschen, Lenoir, & Scheringer, 2003; Lozano, 2012). Thus, green chemistry does not completely encompass sustainability because it does not address social impacts and needs (Abraham, 2006), nor does it explicitly address the economic and time dimensions. Sustainable chemistry, as the term indicates, should encompasses and addresses the four dimensions of sustainability (Lozano, 2008b). It should be noted that both green chemistry and sustainable chemistry are mainly directed at improving operations and production in a company and they need to be linked to the other elements of the company system (strategy and management, organisational systems, procurement and marketing, and assessment and communication) (see Lozano, 2012), as well as to the company's business models, strategies, and practice.

3. Business models for sustainability

The UN Global Compact (UNGC, 2012) proposes the following ten principles, divided into four categories, to help corporations align their business models, strategies, and practices with Sustainability:

- **Human Rights:**
    - *Principle 1:* Businesses should support and respect the protection of internationally proclaimed human rights;

    - *Principle 2:* Businesses should make sure that they are not complicit in human rights abuses;
- **Labour Standards:**
    - *Principle 3:* Businesses should uphold the freedom of association and the effective recognition of the right to collective bargaining;
    - *Principle 4:* Businesses should eliminate of all forms of forced and compulsory labour;
    - *Principle 5*: Businesses should abolish child labour;
    - *Principle 6:* Businesses should eliminate discrimination in respect of employment and occupation;
- **Environment:**
    - *Principle 7:* Businesses should support a precautionary approach to environmental challenges;
    - *Principle 8:* Businesses should undertake initiatives to promote greater environmental responsibility;
    - *Principle 9:* Businesses should encourage the development and diffusion of environmentally friendly technologies;
- **Anti-Corruption:**
    - *Principle 10:* Businesses should work against corruption in all its forms, including extortion and bribery.

According to Teece (2010) "[a] business model is more generic than a business strategy". It articulates the logic, the data, and other evidence that support a value proposition for the customer, and a viable structure of revenues and costs for the enterprise delivering that value. Traditional business models are based on a clear distinction between the acting companies (Perthen-Palmisano & Jakl, 2005), where each company has a specific task or activity. However, traditional business models have been gradually challenged, a shift has been taking place from selling products to providing service solutions to customer needs (Lay, Schroeter, & Biege, 2009; Mont, Dalhammar, & Jacobsson, 2006).

Additionally, businesses must consider the entire life cycle of a product or service, from downstream (*i.e.* extraction), to upstream (*i.e.* disposal), including use (DeSimone & Popoff, 2000; Holliday, Schmidheiny, & Watts, 2002; Robert, 2000). This includes: (1) costs in the usage and service sides, including utilities (steam, cooling water, electricity), labour, waste treatment, inbound and outbound logistics, overheads, and insurance; and (2) environmental and social impacts.

Porter (1998) posited that companies are affected by five major forces (threat of new competition, threat of substitute products or services, bargaining power of customers, bargaining power of suppliers, and intensity of competitive rivalry), which are instrumental in deciding what business model is the most suitable, and eventually, most profitable for the company.

Lay, Schroeter and Biege (2009) identified that manufacturing industries have been considering alternative business concepts that change the relationship between the supplier and buyer of goods and move away from product-focused to service-focused operations. The use of full service contracts, where the customer pays not only for the product but also for maintenance activities as part of the contract, is an example of such an alternative business concept. This relationship is different in the traditional business model in the chemical industry where there are clear distinctions between company actors, Perthen-Palmisano and Jakl (2005) identifying that Company A sells a chemical to Company B and any waste is then dealt with by Company C.

Lay et al. (2009) proposed three alternative business models: (1) leasing, where the supplier becomes a service provider by retaining the ownership and assuming responsibility for maintenance, in this case the customer pays a regular fee for unlimited individual access to the product; (2) renting, similar to leasing, however, the customer does not have unlimited access; and (3) 'product pooling', where the equipment is used simultaneously by several users instead of a sequential mode of use. Agrawal et al. (2012) argued that leasing can be more profitable and greener than traditional business models, especially when the products have higher durability and high use impact. However, leasing can create another problem in situations where consumers' valuations for the product depend on the availability of complementary products (Bhaskaran & Gilbert, 2005).

Mont (2002) proposed the 'product-service systems' (PSS) models, which are focused on addressing the use phase to reduce the total environmental burden of consumption. Tukker (2004) divided them into product-oriented services (including product related services and advice and consultancy), user-oriented services (including product lease, product renting or sharing, and product pooling), and result-oriented services (including activity management/outsourcing and pay per service unit). In this classification 'outsourcing' is considered part of the result-oriented services (Tukker, 2004). Mont (2002) provided a more complete classification, encompassing: (1) products/services/combinations/substitutions; (2) services at the point of sale; (3) different concepts of product use (subdivided into use oriented and result oriented); (4) maintenance services; and (5) revalorisation services. PSS models require close collaboration with suppliers and service producers or final consumers. This requires changes in levels of exchanged information, but also in the nature of relationships between the actors in the network (Lockett, Johnson, Evans, & Bastl, 2011).

As it can be observed a number of alternative business models, grouped under the PSS term, have been proposed to reduce the environmental burdens in the use of products. They have been switching towards a service approach, where the products are no longer sold, but 'rented' or 'leased' and the responsibility to deal with such products lies with the leaser rather than with the user.

4. Collaboration as a key element for sustainability

This section discusses on a key element to achieve sustainability: collaboration (see Clarke & Roome, 1999; Lozano, 2007, 2008a; UN, 1992). Collaboration harvests its benefits from differences in perspectives, knowledge and approaches, solving problems while at the same time offering benefits to all those involved in the process. Some of the benefits of collaboration include the ability to optimise financial and human capitals, access markets and knowledge, enrich creativity, avoid confrontation, decrease time needed to accomplish objectives, and make processes more efficient (Fadeeva, 2004). Other benefits include being action orientated, offering benefits to all the players, reducing or removing conflicts, and in some cases trans-disciplinary learning (Lozano, 2007). However, collaboration has inherent difficulties. Genefke (2000) mentions two types of difficulties, naming them as costs. The first, the coordination costs, refer to operational dependence between the activities of the different actors. The second, the vulnerability costs, refer to the risk of safeguarding the important and unique resources. The two costs are complemented with three practical difficulties: Information (referring to who gets the benefits and the real, or hidden, agenda); Bargaining (how to split the gains); and Free riding: those who choose not to participate but still get the benefits (Chilosi, 2003).

Porter (1998) also emphasised the potential benefits of non-competitive approaches by remarking that companies could choose strategies that avoid warfare and make the industry better off, even though the firm might give up potential profits and market share in the short-term. Taking such an approach, industries could experience sustainable growth with better profits for each of the companies in the long-term. It is implicit that such strategies must follow Sustainability principles and not solely focus on the economic bottom line, as is commonly done. Paradoxically, competition needs collaboration and vice versa, and there needs to be competition for industries to grow more efficient. At the same time there also needs to be collaboration, especially in current global times, to make initiatives and changes that would create new models and ways of thinking to improve their sector, and their internal and external environments, both natural and social. Ancarani and Shankar (2002) offer the example of Symbian, a joint venture between Nokia, Sony-Ericsson, Motorola, Siemens, and Psion, usually competitors in the mobile phones market. Collaboration through Symbian allowed those companies to take advantage of their experiences and helped them to create an operating system for third generation mobile phones that could compete against Microsoft's operating system.

Two Japanese concepts can be helpful in understanding and implementing collaboration: Kyosei and keiretsu. Kyosei means "spirit of co-operation". The Kyosei process has five stages, or layers: stage 1 Economic survival; stage 2 Co-operating with labour; stage 3 Co-operating outside the company; stage 4 Global activism; and stage 5 The government as a Kyosei partner (Kaku, 2003). In the keiretsu system companies engage into long-term cooperative systems with their suppliers (Hill & Jones, 2001). This can bring long-term benefits through better standardisation, quality improvements, and products and services that are more in accordance with the needs of the outsourcing organisation (Lozano, 2008a).

It should be noted that in Kaku's (2003) approach, Kyosei is biased towards social aspects while environmental ones are not explicitly addressed. Lozano (2008a) proposed to expand the Kyosei approach to accommodate environmental issues to help reach a situation of worldwide stability in which the majority of the world's population is no longer living at a level of basic survival, and which incorporates the environment, and societies (including civil society, governments, and corporations).

5. The concept of Chemical Leasing

The concept of Chemical Leasing (ChL) has been developed as a business model to help the chemical industry to better contribute to sustainability. Traditional sales business models for chemicals have offered no incentive to prevent over-consumption, or promote knowledge transfer for efficient use of chemicals and effective recycling (Ohl & Moser, 2007), or for reducing environmental impacts and ultimately eliminating hazardous materials from products and processes. The United Nations Industrial Development Organization (UNIDO, 2011, p. 2) define ChL as "a service-oriented business model that shifts the focus from increasing sales volume of chemicals, toward a value-added approach". The ChL concept is aimed at solving this by including: more efficient use of, and reduced risk from, those chemicals; protection of human health; improved economic and environmental performance of participating companies; and enhanced access for those companies into new markets (UNIDO, 2011). Joas (2008) identified that economic advantages of ChL are shared between the chemical supplier and user in terms of higher earnings, through reduced production and reduced consumption costs respectively.

While a number of questions have been raised in respect of ChL, including increased dependency of chemical users on their suppliers, particularly if longer-term contracts are signed, and the potential for technical and logistical problems (see for example Plas, 2008), Jakl and Schwager (2008) proposed that ChL supports and enhances a Cleaner Production (CP) approach where "application of an integrated preventative environmental strategy to processes, products and services" both increases efficiency and reduces risks to humans and the environment (see UNEP, 2006; UNIDO, 2002).

Under the value-added approach used in the ChL concept, rather than generating profit by high volume of sales to companies using its chemicals, the chemical producer/supplier -

who remains the owner of the chemicals - is paid for the service provided by them (for example - instead of volume or weight of chemicals, they might use square meters of painted surface). Breaking the link between sales and profit can result in both increased efficiency in the application of chemicals within a specific production process and also lead to optimization of that process as a way of reducing the volumes of chemicals needed to carry it out, minimizing any chemical waste or discharges generated by the process (see for example Geldermann, Daub, & Hesse, 2009; Gilbert & Downs, 2010; Ohl & Moser, 2007). Gilbert and Downs (2010) identified that a basic assumption with ChL is that the user pays for services rendered by the chemical rather than purchasing it.

The relationship between manufacturer and user is based not only on the sale of chemicals, but also on the associated expertise (the manner and conditions of application, the concept of recycling and disposal). The manufacturer sells chemicals, including expertise for their effective use and, within ChL business models; the responsibility of the producer and service provider is extended and may include the management of the entire life cycle of a chemical. In addition to users and producers of chemicals, a project may include optimization or modification of existing processes with the participation of equipment manufacturers, recycling companies and other interested parties (Figure 2).

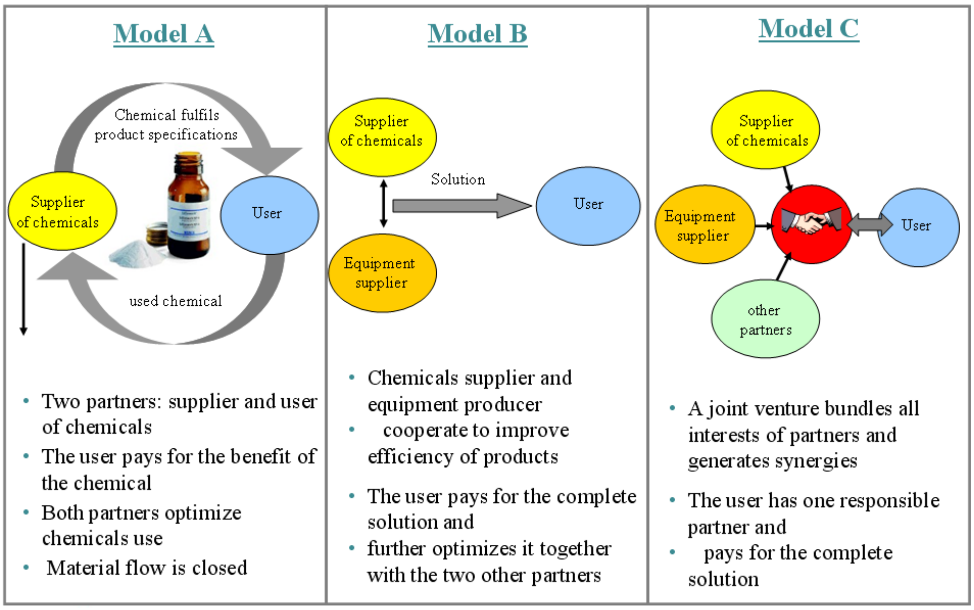

Figure 2 - Possible partners in chemical leasing business models
Source: (Jakl & Schwager, 2008)

The process optimization aspect differentiates ChL from other service-oriented business models, such as traditional leasing agreements and CMS (BiPRO, 2010). Traditional leasing arrangements provide a firm – for example the chemical supplier – with direct control over the way its products are used. Under such an arrangement, the chemical user simply pays a regular amount to use those chemicals, has a minimal relationship with the supplier, and there is no element of cooperation in areas such as exchange of expertise or any efforts to reduce user costs by minimising waste (Agrawal et al., 2012). By contrast CMS is seen as a model with closer parallels to ChL where a relationship is built up over a longer period of time between the user and a management company. However, while that company deals with all aspects of managing the chemicals from purchase through to disposal, it may not be the producer of the chemicals and may also not be concerned with increasing the efficiency of those chemicals. Anttonen (2010) identified CMS as services that aim to reduce chemical usage and offer “chemical solutions instead of chemical products”, also noting that both CMS and ChL seek to align the relationship between service provide and customer so that “they share incentives to move towards more efficient use of materials and reduce waste” (page 201).

CMS and ChL also have clear overlaps. In both concepts there has been a move away from the traditional chemical supplier-buyer relationship where the supplier seeks to increase volumes sold to increase profits while the buyer seeks to decrease the volumes purchased to reduce costs. In an aligned incentives model the supplier becomes the service provider while the buyer becomes the service user. Both sides share a common aim of decreasing costs through reduction in chemical consumption, waste minimization, and optimizing the performance of the chemicals.

ChL also has similarities with Product Service Systems (PSSs) literature, discussed previously. For example, the change that Xerox undertook from a selling position towards a document management service. This moved the company away from only limited relationship between producer and supplier at the point of sale and towards a closer relationship based on the provision of a service by the supplier throughout the life of the product (Lockett et al., 2011).

Schwager and Moser (2005) identified that different ChL approaches may be necessary depending on who owns the substance (chemical) to be used, who owns and operates the plant where it is to be used, and where that plant is located, together with country specific factors which can influence whether ChL is an appropriate model or not. Schwager and Moser (2005) further noted that only chemicals which do not form part of the final product, and which are highly concentrated in the waste are most appropriate for the application of ChL, with potential chemicals including high risk and high value substances. A table of potential chemicals for which the ChL model may be applicable is provided in Table 1, which shows that they are mainly non-reactants and, to a great extent, easy to recover.

Table 1 – Chemicals that could be used in Chemical Leasing business models

Application	**Chemicals**	**Activities involved**
Cleaning/degreasing solvents	Solvent agents	Treatment of iron/steel; treatment of non-ferrous metals; surface treatment; electronic motors, generators; electronics
Adsorption/desorption	e.g. activated carbon	Chemical products; printing; mineral oil processing; food and stimulants; electrical engineering
Pickling	e.g. hydrochloric acid; sulphuric acid; nitric acid; hydrofluoric acid	Treatment of iron/steel; manufacture of plastic products; surface treatment
Synthesis (e.g. polycondensation)	e.g. dimethylformamide, butyl acetate, dichloromethane, chlorobenzene	Manufacture of chemical parent substances; manufacture of chemical fibres
Extraction	e.g. chloroform, chlorobenzene, dichloromethane, hexane, methanol, propanol, butanol, acetone, acetic ester, ethanol	Manufacture of chemicals; manufacture of chemical fibres; manufacture of pharmaceutical products; detergent and cleaning agents; manufacture of pyrotechnical products; photochemical products; manufacture of other chemical products; manufacture of essential oils
Cooling/lubrication	Emulsions	Treatment of iron/steel; treatment of non-ferrous metals; electronic motors,

		generators; pumps/compressors; agricultural and forestry equipment; manufacture of machine tools; other machinery, conveyors lubrication
Textile finishing/ mercerization	Caustic lye of soda	
Catalysis	Catalytic converters	Chemical products; mineral oil processing
Cooling	Ammonia, pentane	Abbatoirs and meat-processing; fish processing; manufacture of fruit and vegetable juices; wholesale in fish and meat products
Heating – heat transfer oils	e.g. isododecane	Manufacture of rubber and plastic products

Source: (Schwager & Moser, 2005)

The ChL implementation does not appear to be region-specific. There are some examples of ChL literature which focus on its implementation in Austria and Germany (the countries whose Governments were involved in funding pilot projects through UNIDO), in the United Kingdom (see Geldermann et al., 2009; Gilbert & Downs, 2010), of on-going projects in Serbia, Sri Lanka and Colombia, and new initiatives in Brazil, Croatia, Nicaragua, Russia, Ukraine and Uganda (see UNIDO, 2011). Table 2 provides an overview of ChL case studies in the literature, including additionally activities in Egypt and Mexico, and identifying both the economic and environmental benefits achieved by the companies participating in those studies. Table 2 illustrates that in all cases there are both economic and environmental benefits for the participating firms, and that those benefits occur across a range of industry types and different chemicals. One case study in Columbia identified a one year cost saving of US$ 1.8 million in transport and storage costs, while other studies in Austria, Egypt and Russia identify a 100% reduction in hazardous waste.

Table 2 – Review of ChL Case Studies in the Literature

Country	Sector/Industry of chemical user	Chemicals/Activity	Headline Economic Benefits	Headline Environmental benefits
Austria	Automotive industry	Solvents for metal cleaning	Predicted savings on energy, spare parts, volume of solvents and stabilisers used	97% decrease in emissions to environment from suppliers
Austria	Machinery and metal goods industry	Solvents for paint stripping	50% reduction in new product provided by supplier and around 50% reduction in waste volume	100% reduction in hazardous waste (supplier); reduction in raw materials
Egypt	Manufacture of electrical equipment	Electrostatic powder coatings	Forecast US$ 68,000 annual saving for chemical user.	Reduction in raw materials, energy, emissions and waste. User side 100% reduction of emissions to environment
Egypt	Automotive industry	Hydrocarbon solvent (mixture of 40-50% toluene plus butanol and ethanol	Reduction in solvent consumption per vehicle (from 1.5L to 1.0L/vehicle). 10-15% saving on new product through recycling.	80-100 % reduction of hazardous waste for supplier and 100% for user. User sees 15% decrease in emissions to environment
Egypt	Hot dip galvanisation	flux (ammonium chloride and zinc chloride) for zinc galvanisation	Forecast US$ 200,000 direct annual benefit, plus cost reduction through reduced consumption of zinc	Recovery of waste (no longer discharged to sewer system); reduced solid waste through zinc ash recovery and hard zinc recycling
Mexico	Sugar mills (sugar cane industry)	biodegradable oils and greases for lubrication of equipment including pumps and conveyor belts	50% reduction in new product (supplier/user side); increased production time and increased equipment lifetime (user side)	25% reduction in hazardous waste and 25% reduction in emissions to environment - for both supplier and user
Mexico	Electroplating	nickel for electroplating	22% reduction in nickel consumption (from 585 to 420 kg/annum) and potential savings of around US $10,000 year	Reduction in requirement for new chemicals. Reduction in hazardous waste for both supplier and user
Russia	Water purification	reagents - iron chloride ($FeCL_3$) and sodium hydroxide (NaOH) - for wastewater purification	50% cost reduction and 50% reduction in required chemical consumption	Hazardous waste concentration below max permissible by law; up to 98% reduction in organic compounds emitted to environment
Colombia	Oil and Gas Sectors	emulsion breaker and water purifier to minimize water content in oil	Cost savings through decreased chemical use, oil recovery, lower maintenance costs and reduction in treatment process costs. User savings of US $1.8 million (2008-2009) for transport and storage of chemicals; supplier savings of US $164,620 (2008) and	Reduced polymer consumption and fewer polymer residues; reduced impact of treated water; no sub-products from chemical production process

			US $249,418 (2009).	
Serbia	Beverage sector	lubricant containing alkyl amines and acetic acid (corrosive and toxic) for conveyor lubrication	Total cost savings per packaging line = €5,700 per year. Reduced cost for lubrication.	No water or chemicals required for pre-treatment of waste water treatment; 30% reduction in chemicals used for lubrication
Serbia	Confectionary sector	Bonding of cardboard boxes	Total cost savings are about 20.000 EUR (30%). Reduced costs for adhesive, electricity, maintenance, spare parts	Less use of adhesive (about 30%), less energy use, less waste
Serbia	Metalworking	Metal cleaning by chlorinated solvents	Total cost savings about 70000 EUr. Reduced costs for solvent, waste treatment	Less waste, less solvents emission
Sri Lanka	Publishing sector	inks (which include VOCs) for newspaper printing	Up to 7% reduction in ink consumption (3-year target). Direct ink cost saving of US $50,000 per annum	Reduction in ink waste, waste water.
UK	Oil production	Caesium formate brine for remedial oil well maintenance	Very low level of chemical loss (this is a rare, high value chemical)	Reduced consumption and waste; low levels of discharge to environment

Sources: Case studies for Austria, Egypt, Mexico and Russia from Jakl and Schwager (2008); for Colombia, Serbia and Sri Lanka from UNIDO (2011); and UK from Gilbert and Downs (2010).

A significant aspect of ChL in Europe is its alignment with the requirements of to protect human health and the environment while maintaining and enhancing competitiveness in the EU chemical industry (European Commission, 2007). In this service-oriented business model, the chemical supplier is able to provide all the necessary information on the chemical through knowledge transfer and also able to manage hazards and risks through the service it offers to the chemical user. This also has the potential benefit, according to Geldermann et al. (2009) of reducing research and development costs for the chemical user, particularly where “the use of chemicals is not part of their core competencies”.

Satric et al. (in press) indicated the following the benefits for the ChL partners: increased ability to create value for both parties; flexibility and speed of joint responses to changing market or customer needs and expectations; and optimization of costs and resources. Whilst applying the principle of mutually beneficial supplier relationships typically leads to: establishing relationships that balance short-term gains with long-term considerations; pooling of expertise and resources with partners; identifying and selecting key suppliers; communicating more clearly and openly; sharing information and future plans; establishing joint development and improvement activities; and inspiring, encouraging and recognizing improvements and achievements by suppliers.

It is widely acknowledged that the functions of chemicals differ for each industrial process; this depends on the context where the company operates, the equipment it uses, and the order of its unit operations. Most chemical users for whom chemical processes are not in their core business (e.g., surface protection of metal in the metalworking industry) usually have limited knowledge on how to optimise the process to reduce the chemicals consumption. In the traditional business model, the interest of the chemical producer is to sell as many chemicals as possible, whilst the ChL model is based on collaboration, optimisation, and reduction of chemicals consumption.

6. Discussion

This section provides a discussion on the ChL concept based on critical reflections of the previous sections.

The first argument is on which type of chemicals can ChL be applied to. As Schwager and Moser (2005) indicated, these must be chemicals that do not form part of the final product. Good candidates include chemicals which are highly concentrated in the waste as being most appropriate for the application of ChL. Potential chemicals including high risk and high value substances such as caesium formate brine, a rare specialist chemical with limited availability, used for well-head maintenance in the oil production industry (see Gilbert and Downs, 2010). Therefore, it can be considered that ChL is only applicable to non-reactant chemicals that are indirectly used in processes, i.e. not ending up as part of the final product.

The second argument pertains the focus of the concept, as indicated in the green and sustainable chemistry approaches (see Anastas & Eghbali, 2010; Anastas et al., 2000; Anastas & Kirchhoff, 2002; Anastas & Warner, 2000; Collins, 2001). Here, the purpose is to use chemicals and chemical techniques to reduce negative environmental and health impacts, and ultimately eliminate the use of hazardous materials throughout the life cycle of such products. In this, the precautionary principles (see UNGC, 2012) is sine qua non.

The third argument relates to the company system, where ChL links operation and production with business models, i.e. to management and strategy (as posited by Lozano, 2012). This arguments posits that these two elements (or functions) of the company need to be inter-linked in order to be aligned (see Lozano, 2008a) and create a more synergetic, holistic, and systemic approach in addressing sustainability.

The fourth argument posits that in ChL the supplier becomes a service provider by retaining the ownership and assuming responsibility for maintenance, in this case the customer pays a regular fee for unlimited individual access to the product (as indicated by Lay, Schroeter, & Sabine, 2009). Therefore, the approach changes from traditional selling of products to providing a service. However, the question arises as to whether the service provider has the capacity to undertake that maintenance responsibility, particularly if it involves employing additional staff that must become familiar with the processes of the chemical user. To become a service provider, the chemical supplier is thus changing the nature of its own core business – the production of chemicals – and this might be a barrier to change. This could pose a problem if the chemical supplier is a small company with limited resources. Another problem that might arise is that of power, where a big chemical supplier has a large bargaining power over the smaller customer. A disincentive for the ChL is when a customer is so small that providing the service become a cost rather than a benefits for all.

The fifth argument pertains to setting the price for the service. This price needs to include the costs to the service provider (downstream, upstream, and use (DeSimone & Popoff, 2000; Holliday et al., 2002; Robert, 2000). These costs should include costs utilities (steam, cooling water, electricity), labour, waste treatment, inbound and outbound logistics, overheads, and insurance, as well as generating a profit for the service provider. An important question that arises is: what percentage of the delivered mass is supposed to return to the company that leased the product?

The sixth argument specifies that collaboration is a prerequisite for ChL, where there are benefits for all the stakeholders engaged in the relationship (as indicated by Fadeeva, 2004; Lozano, 2007, 2008a). There are inherent challenges in this, such as coordination costs, vulnerability costs, information exchange, and how to split the benefits (i.e. how to set the price of the service). The concepts of Kyosei and keiretsu (see Hill & Jones, 2001; Kaku, 2003; Lozano, 2008a) can help to overcome such difficulties by explaining the importance of inter-company relations in the short, medium, and long term. They also indicate that there have to be benefits for all parties. This raises the following questions: what is the shortest term a lease should be signed, so that it is beneficial for all parties? And, what are the implications or consequences if the relationship breaks down (or if one of the companies goes bankrupt)?

The seventh argument pertains to sustainability's dimensions (as posited by Lozano, 2008b). ChL mainly focuses on reducing environmental impacts (refer to Jakl & Schwager, 2008; Plas, 2008; Satric et al., in press; Schwager & Moser, 2005; UNIDO, 2011), which result in economic benefits for the parties. Although it can have benefits to occupational health(see European Commission, 2007), its contribution to the social dimension is rather limited. This limits the ChL contribution to the UNGC to principles 7 to 9 (UNGC, 2012). Arguments two and five demonstrate how ChL can focus on the long-term, through collaboration and the precautionary principle, and therefore address the time dimension.

These arguments show that chemical leasing can be a more efficient business model alternative to traditional industry practice, bringing economic and environmental benefits to suppliers and users, but its use is restricted to some specific types of chemicals (such as solvents and catalysts). The ChL concept is a new business model that provides value to the companies involved in it, and at the same time reducing the negative impacts to the environment. This poses a challenge on how to get more companies involved in the concept.

7. Conclusions

Chemistry has been recognised as an important discipline for contributing to the design and implementation of sustainable development strategies. Green chemistry and sustainable chemistry involve a reduction and eventual elimination of hazardous substances. Green and sustainable chemistry focus on improving the operations and production of companies through the design or modification of chemical reactions to be more environmentally friendly and not on better management and control of the use of chemicals in an industrial process. The green and sustainable chemistry approaches, therefore, need to be complemented with other efforts that help the company as a whole and its different elements, as well as addressing the social dimension.

Within this context chemical leasing has been recently developed as an alternative to help use chemicals more efficiently and reduce waste and close the feedback loop more effectively. It complements other green chemistry approaches, e.g. chemical management systems and legislation such as REACH. Nonetheless, current studies on the topic have been mainly empirical and descriptive, and generally identify only short-term benefits from process change, and there is limited theoretical work on the topic. This paper has been aimed at providing clarity through critical reflections to the questions posed by Satric, Carpenter, and Lozano (in press) about the limitations, scope, and reach of the ChL concept.

Chemical Leasing has been developed as an alternative business model to traditional selling of chemicals; however, the focus has been on practical applications. This paper grounds the concept in academic discussions, from which the following definition can be proposed:

> *"Chemical Leasing is a business model based on collaborative approaches between two or more industrial partners, where one uses the chemical and the other provides their service, so that environmental impacts and use of hazardous chemical are reduced. As a principle of leasing, it involves unlimited access to chemicals from the user. The types of chemicals that are covered by the concept are non-reactant products that are easy to recovery and have a high recovery rate (over 80%), for example solvents and catalysts, and that are not part of the final product. Good candidates include chemicals that are high risk for human health or the environment and have high value."*

Chemical leasing shows great potential to help move the chemical industry to become greener, through business models innovations and collaboration. Although it has only existed as a concept for around a decade, there is already empirical evidence of the economic and environmental benefits to be gained by both the suppliers and the users of chemicals, through collaborative activities. However, currently the majority of those collaborations are small scale and have resulted from funding the activities of UNIDO and its Cleaner Production Centres. In practical terms, it is important to provide evidence through the pooling of knowledge and experience by producers and users to promote its use by larger companies where there is the potential for much more significant economic and environmental gains. Future research is needed looking at whether ChL is more relevant for big companies, small ones, or a combination, and if so of which type, and to answer the questions that this paper has raised, such as setting the price of the service, shortest lease time, percentage of recovery, what to do if one of the partners fails in its obligations, and how to get more companies involved in the concept.

The future of green and sustainable chemical industry will be greatly enhanced by business models that involve dialogue, collaboration, and pooling of the knowledge and experiences by producers and users.

References

Abraham, M. A. (2006). *Principles of Sustainable Engineering Sustainability Science and Engineering: Defining Principles*. Amsterdam, The Netherlands: Elsevier, B.V.

Aftalion, F. (2001). *A History of the International Chemical Industry*. Philadelphia, USA: Chemical Heritage Press.

Agrawal, V. V., Ferguson, M., Toktay, L. B., & Thomas, V. M. (2012). Is Leasing Greener Than Selling? *Management Science, 58*(3), 523-533. doi: http://dx.doi.org/10.1287/mnsc.1110.1428

Anastas, P. T., & Breen, J. J. (1997). Design for the environment and Green Chemistry: the heart and soul of industrial Ecology. *Journal of Cleaner Production, 5*(1-2), 97-102.

Anastas, P. T., & Eghbali, N. (2010). Green chemistry: Principles and practice. *Chemical Society Reviews, 39*, 391-312.

Anastas, P. T., Heine, L. G., & Williamson, T. C. (2000). Green Chemical Syntheses and Processes: Introduction. In P. T. Anastas, L. G. Heine & T. C. Williamson (Eds.), *Green Chemical Syntheses and Processes*. Washington, DC: American Chemical Society.

Anastas, P. T., & Kirchhoff, M. M. (2002). Origins, current status, and future challenges of green chemistry. *Accounts of Chemical Research, 35*(9), 686-694.

Anastas, P. T., & Warner, J. C. (2000). *Green Chemistry: Theory and Practice*. New York: Oxford University Press.

Ancarani, F., & Shankar, V. (2002). Symbian: Customer interactions through collaboration and competition in a convergent industry. Milan/Maryland: Universita Commeciale Luigi Bocconi/University of Maryland.

Anttonen, M. (2010). Greening from the Front to the Back Door? A Typology of Chemical and Resource Management Services". *Business Strategy and the Environment, 19*(3), 199-215.

Arora, A., Landau, R., & Rosenberg, N. (1998). *Chemicals and Long-Term Economic Growth. Insights from the Chemical Industry*. US: John Wiley & Sons, Inc.

Banerjee, S. (2010). Reach-like regulations enacted globally – A regulatory world tour Retrieved 9th December, 2012, from http://www.icis.com/Articles/2010/05/31/9362538/reach-like-regulations-enacted-globally.html

Bhaskaran, S. R., & Gilbert, S. M. (2005). Selling and Leasing Strategies for Durable Goods with Complementary Products. *Management Science, 51*(8), 1278-1290. doi: 10.1287/mnsc.1050.0421

BiPRO. (2010). Chemical Leasing as a model for sustainable development with test procedures and quality criteria on the basis of pilot projects in Germany. Dessau-Rosslau: Beratungsgesellschaft für integrierte Problemösungen. German Federal Environment Agency.

Böschen, S., Lenoir, D., & Scheringer, M. (2003). Sustainable chemistry: starting points and prospects. *Naturwissenschaften, 90*(3), 93-102. doi: 10.1007/s00114-002-0397-9

Carson, R. (2000). *Silent Spring*. London: Penguin Books.

Chemical Engineering Progress. (2008). A Century of Triumphs (Vol. November, pp. 5-25): Chemical Engineering Progress.

Chilosi, A. (2003). Coordination, cooperation, and the extended Coasean approach to economic policy. Pisa: Facolta di Scienze Politiche.

CIRS. (2012). Regulations on Safe Management of Hazardous Chemicals in China - Decree 591. Retrieved 29 January, 2012

Clarke, S., & Roome, N. (1999). Sustainable Business: Learning - action networks as organizational assets. *Business Strategy and the Environment, 8*, 296-310.

Collins, T. (2001). Toward Sustainable Chemistry. *Science, 291*, 48-49.

DeSimone, L. D., & Popoff, F. (2000). *Eco-Efficiency. The Business Link to Sustainable Development*: MIT Press.
ECIC. (2012). Facts and Figures 2011: The European chemical industry in a worldwide perspective. Belgium: CEFIC.
European Commission – Environment. (2012). REACH. Brussels, Belgium: European Commission.
Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) (2006).
European Commission. (2007). REACH in brief. Brussels, Belgium: European Commission Environment Directorate General
Fadeeva, Z. (2004). Promise of sustainability collaboration - potential fulfilled? *Journal of Cleaner Production, 13*, 165-174.
Feitshans, I. L. (1989). Law and Regulation of Benzene. *Environmental Health Perspectives, 83*, 299-307.
Geldermann, J., Daub, A., & Hesse, M. (2009). Chemical Leasing as a model for sustainable development (Vol. Research Paper Nr. 9). Göttingen, Germany: Georg-August-Universität Göttingen.
Genefke, J. (2000). Collaboration costs! Aarhus: University of Aarhus. Department of Management.
Gilbert, Y. M., & Downs, J. D. (2010). *Towards sustainable chemical use through chemical leasing*. Paper presented at the SPE Middle East Health, Safety, Security and Environment Conference, Bahrain.
Glavič, P., & Lukman, R. (2007). Review of sustainability terms and their definitions. *Journal of Cleaner Production, 15*, 1875-1885.
Hartnell, R. (2011). $1.23 trillion sliced and diced. *ICIS Chemical Business,* 12-18.
Hayes, R. B. (1988). Review of occupational epidemiology of chromium chemicals and respiratory cancer. *The Science of the Total Environment, 71*(3), 331-339.
Hill, C. W., & Jones, G. R. (2001). *Strategic Management: An integrated approach* (Fifth ed. ed.). U.S.A.: Houghton Mifflin Company.
Holliday, C. O. J., Schmidheiny, S., & Watts, P. (2002). *Walking the Talk. The Business Case for Sustainable Development*. Sheffield: Greenleaf Publishing.
Jakl, T., & Schwager, P. (2008). Lessons Learned – The Way Forward *Chemical Leasing Goes Global: Selling Services Instead of Barrels – A Win-Win Business Model for Environment and Industry* (pp. 221-226). Vienna, Austria: Springer.
Joas, R. (2008). The Concept of Chemical Leasing *Chemical Leasing Goes Global: Selling Services Instead of Barrels – A Win-Win Business Model for Environment and Industry* (pp. 17-26). Vienna, Austria: Springer.
Kaku, R. (2003). The path of Kyosei, in Harvard Business Review on Corporate Responsibility. *Harvard Business School Press*.
Kirchhoff, M. M. (2005). Promoting sustainability through green chemistry. *Resources, Conservation and Recycling, 44*, 237-243. doi: 10.1016/j.resconrec.2005.01.003
Lay, G., Schroeter, M., & Biege, S. (2009). Service-based business concepts: A typology for business-to-business markets. *European Management Journal, 27*, 442-455. doi: 10.1016/j.emj.2009.04.002
Lay, G., Schroeter, M., & Sabine, B. (2009). Service-based business concepts: A typology for business-to-business markets. *European Management Journal, 27*, 442-455.
Lockett, H., Johnson, M., Evans, S., & Bastl, M. (2011). Product Service Systems and supply network relationships: an exploratory case study. *Journal of Manufacturing Technology, 22*(3), 293-313. doi: 10.1108/17410381111112684
Lozano, R. (2007). Collaboration as a pathway for sustainability. *Sustainable Development, 15*, 370-381. doi: 10.1002/sd.322
Lozano, R. (2008a). Developing collaborative and sustainable organisations. *Journal of Cleaner Production, 16*, 499-509. doi: 10.1016/j.jclepro.2007.01.002

Lozano, R. (2008b). Envisioning sustainability three-dimensionally. *Journal of Cleaner Production, 16*(17), 1838-1846.
Lozano, R. (2012). Towards better embedding sustainability into companies' systems: an analysis of voluntary corporate initiatives. *Journal of Cleaner Production, 25*, 14-26. doi: 10.1016/j.jclepro.2011.11.060
Meyer, H.-P. (2011). Sustainability and Biotechnology. *Organic Process Research and Development, 15*(1), 180-188.
Miller, G. T. (2002). *Living in the Environment* (12th ed.). Belmont, California, USA: Thomson Learning, Inc.
Mont, O. (2002). Clarifying the concept of product–service system. *Journal of Cleaner Production, 10*, 237-245.
Mont, O., Dalhammar, C., & Jacobsson, N. (2006). A new business model for baby prams based on leasing and product remanufacturing. *Journal of Cleaner Production, 14*, 1509-1518. doi: 10.1016/j.jclepro.2006.01.024
OECD. (2001). OECD Environmental Outlook for the Chemicals Industry. Paris: Organisation for Economic Co-operation and Development.
Ohl, C., & Moser, F. (2007). Chemical Leasing Business Models – A Contribution to the Effective Risk Management of Chemical Substances. *Risk Analysis, 27*(4), 999-1007. doi: 10.1111/j.1539-6924.2007.00938.x
Perthen-Palmisano, B., & Jakl, T. (2005). Chemical Leasing. Cooperative business models for sustainable chemicals management. *ESPR – Environ Sci & Pollut Res, 12*(1), 49-53.
Plas, C. (2008). Enhancing the Acceptance of Chemical Leasing *Chemical Leasing Goes Global: Selling Services Instead of Barrels – A Win-Win Business Model for Environment and Industry* (pp. 27-33). Vienna, Austria: Springer.
Porter, M. E. (1998). *Competitive strategy. Techniques for analyzing industry and competitors*. New York: The Free Press.
Redclift, M., & Sage, C. (1994). *Strategies for sustainable development: local agendas for the Southern Hemisphere*. West Sussex, UK: John Wiley & Sons Ltd.
Robert, K.-H. (2000). Tools and concepts for sustainable development, how do they relate to a general framework for sustainable development, and to each other? *Journal of Cleaner Production, 8*, 243-254.
Satric, V., Carpenter, A., & Lozano, R. (in press). Chemical Leasing as a Service Oriented Business Model: A case study from Serbia. *Resources, Conservation, and Recycling*.
Schwager, P., & Moser, F. (2005). The Application of Chemical Leasing Business Models in Mexico. *ESPR – Environ Sci & Pollut Res, 13*(2), 131-137.
Stoughton, M., & T. Votta, T. (2003). Implementing service-based chemical procurement: Lessons and results. *Journal of Cleaner Production, 11*(8), 839-349.
Teece, D. J. (2010). Business Models, Business Strategy and Innovation. *Long Range Planning, 43*, 173-194.
Tolbert, P. E., Eisen, E. A., Pothier, L. J., Monson, R. R., Hallock, M. F., & Smith, T. J. (1992). Mortality studies of machining-fluid exposure in the automobile industry: II. Risks associated with specific fluid types. *Scandanavian Journal of Work, Environment and Health, 18*(6), 351-336.
Tomatis, L., Agthe, C., Bartsch, H., Huff, J., Montesano, R., Saracci, R., Wilbourn, J. (1978). Evaluation of the Carcinogenicity of Chemicals: A Review of the Monograph Program of the International Agency for Research on Cancer (1971 to 1977). *Cancer Research, 38*, 877-885.
Tukker, A. (2004). Eight types of product-service system: Eight ways to sustainability? Experiences from Suspronet. *Business Strategy and the Environment, 13*, 246-260.
Tundo, P., Anastas, P., Black, D. S., Breen, J., Collins, T., & Memoli, S. (2000). Special topic issue on green chemistry--synthetic pathways and processes in green chemistry. Introductory overview. *Pure and Applied Chemistry, 72*(7), 1207-1230.

UN. (1992). Agenda 21. Rio de Janeiro, Brazil: United Nations.
UN. (2002). World Summit on Sustainable Development Plan of Implementation. Johannesburg, South Africa: United Nations.
UNECE. (undated). About the GHS – Globally Harmonized System of Classification and Labelling of Chemicals (GHS). New York, USA: United Nations Economic Commission for Europe.
UNEP. (2006). *Strategic Approach to International Chemicals Management: SAICM texts and resolutions of the International Conference on Chemicals Management.* Paper presented at the International Conference on Chemicals Management. 4-6 February, 2006, Dubai, United Arab Emirates.
UNGC. (2012). The Ten Principles Retrieved 18 January, 2013, from http://www.unglobalcompact.org/AboutTheGC/TheTenPrinciples/index.html
UNIDO. (2002). Manual on the Development of Cleaner Production Policies – Approaches and Instruments. Vienna, Austria: United Nations Industrial Development Organization.
UNIDO. (2011). Chemical leasing: A global success story. Innovative business approaches for sound and efficient chemicals management. Vienna, Austria: United Nations Industrial Development Organization.