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ECONOMIC FEATURES OF CHEMICAL LEASING

**Series on Risk Management
No. 37**

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OECD Environment, Health and Safety Publications

Series on Risk Management

No. 37

ECONOMIC FEATURES OF CHEMICAL LEASING

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INTER-ORGANIZATION PROGRAMME FOR THE SOUND MANAGEMENT OF CHEMICALS

A cooperative agreement among **FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank and OECD**

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FOREWORD

This document presents a report on the Economic Features of Chemical Leasing. It has been developed within the framework of the OECD Issue Team on Sustainable Chemistry. The report was produced by Risk & Policy Analyst (RPA) (Marco Camboni and Shaun da Costa) building upon an initial background report conducted by BiPro (Reinhard Joas). The report incorporates input from the Issue Team on Sustainable Chemistry and the Joint Meeting of the Chemicals Committee and Working Party on Chemicals, Pesticides and Biotechnology and is published under the responsibility of the Joint Meeting.

TABLE OF CONTENTS

LIST OF ABBREVIATIONS	10
EXECUTIVE SUMMARY	11
INTRODUCTION.....	13
1.1 Service-Focused Business Models in the Chemical Industry	13
1.2 Study Objectives	15
THE CHEMICAL LEASING BUSINESS MODEL AND ITS MAIN STAKEHOLDERS	16
2.1 The Chemical Leasing Business Model.....	16
POTENTIAL MARKET OF CHL AND EXAMPLES OF PRACTICAL IMPLEMENTATION.....	23
3.1 Past Applications and Potential Market.....	23
3.2 Examples of Application of Chemical Leasing	24
3.2.1 Metal cleaning – Austria/Germany	24
3.2.2 Water purification – Russia.....	25
3.2.3 Well drilling	26
3.2.4 Car coating – Poland	26
COSTS AND BENEFITS, DRIVERS AND BARRIERS	28
4.1 Introduction.....	28
4.2 Policy Drivers	28
4.3 Market Drivers and Benefits.....	28
4.4 Costs and Barriers	30
ANALYSIS OF THE FUNCTIONING OF THE CHEMICAL LEASING BUSINESS MODEL	33
5.1 Introduction.....	33
5.2 Comparative Analysis of ChL with Traditional Contracts	36
5.2.1 Information asymmetries, adverse selection and moral hazard in traditional contracts.....	36
5.2.2 Information asymmetries, adverse selection and moral hazard in ChL contracts	37
5.2.3 Mitigation of ChL problems.....	39
CONCLUSIONS AND RECOMMENDATIONS	40
REFERENCES	43

LIST OF ABBREVIATIONS

Cefic	European Chemical Industry Council
ChL	Chemical Leasing
CMS	Chemical Management Services
CP	Cleaner Production
NCPC	National Cleaner Production Centres
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Co-operation and Development
REACH	Regulation (EC) 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals
SAICM	Strategic Approach to International Chemical Management
UBA	German Federal Environment Agency
UNEP	United Nations Environmental Programme
UNIDO	United Nations Industrial Development Organization
US	United States of America

EXECUTIVE SUMMARY

Chemical Leasing (ChL) is a service-oriented business model that aligns the interests of the chemical supplier with those of the chemical user by compensating the service of the chemical rather than the chemical volume sold and used. This creates a strategic partnership between the two parties, in which the common goal is the reduction of chemical consumption, thus achieving enhanced performances, chemical handling and waste management and, therefore, economic and environmental benefits.

Due to the economic and environmental benefits that ChL can achieve, since the early 2000s UNIDO and some European countries, notably, Austria, Germany and Switzerland, have been promoting the business model as a means to achieve sustainability in the chemical industry.

This study presents a review of the literature on the economic features of the ChL and of similar business models, focusing on the drivers and barriers and comparing their functioning to traditional contracts.

Advanced chemical legislative frameworks have been and are being established in developed and developing countries with the common objective of providing more information to the public and to further involve the chemical industry in reducing the use of hazardous chemicals. Compliance with chemical policy requires constant innovation at the chemical substance level (search for safer alternatives), at the technical process level (search for more efficient processes and technologies) and at organisational level (search for new business solutions) and an enhanced communication of information through the chemical supply chain. It is therefore a strong driver for the uptake of ChL.

Beside policy, the current characteristics of the chemical market, i.e. increased international competition and declining margins, also constitute a driver for the adoption of business models that help in achieving greater efficiency, in maintaining solid relationships between chemical suppliers and customers and in avoiding price underbidding. Moreover, the increase in the demand for greener consumer products may push large retailers to require higher environmental standards of their suppliers, driving the uptake of innovative business models which demonstrate substantial environmental benefits, such as ChL.

Despite these policies and market drivers and the positive results achieved through the implementation of ChL in different countries, the business model still has a limited penetration. Possible reasons are: strict waste legislation, lack of customer demand, liability risks, fear of losing know-how to the supplier and reluctance of the supplier to take on all the investments. A major external barrier is that prospective ChL users are not completely aware of the life-cycle cost of chemicals.

Another hurdle that could affect the uptake of all business models in which chemical management activities are being outsourced, including ChL, is that, when the chemical management activities are performed by individual staff aside other responsibilities (as it is often the case in small and medium-sized enterprises), the transferability is more problematic and the chemical service provider may not be able to reduce the company direct costs, as the salaries of that staff will have to be paid anyway. On the opposite side of the problem, prospective users may have already invested in in-house capacity for chemical management to ensure compliance to strict environmental and health and safety legislation. Therefore,

potential ChL suppliers may find it difficult to improve the chemical management of the users and hence there may be less incentive for such a company to switch to a ChL model.

Servicising contracts, such as ChL, can mitigate information asymmetries and transaction costs through the realignment of incentives in the supplier-user relationship. However, these contracts can also lead to new types of transactional hazards, such as bilateral dependence and monopoly. These have been dealt with in ChL with different mitigation strategies, crafted to the peculiarities of the companies involved.

On the basis of the identified barriers and of the recommendations provided by different authors, some initiatives are suggested to promote the efficient application of the model, focusing on increasing awareness of ChL and its advantages among stakeholders, offering support in the form of legal advice in drafting contracts and facilitating the uptake of ChL through the application of reduced value added tax (VAT) rates.

INTRODUCTION

1.1 Service-Focused Business Models in the Chemical Industry

The development of service-focused business models started during the 1970s as a response to emerging game-changing trends such as an increase and change in nature of international competition, improved education level and standard of living of employees and consumers and increased awareness of consumers about available options as a result of the development of information technology (Grönroos, 1994). Traditional business models focus on cost reduction efforts and scale economies that, in the long run, may damage the quality of the product/service provided, the company working environment and the relationships with the other stakeholders, in particular with the customers, with the ultimate result of profitability problems (Normann, 1982). The reason to focus on service is the belief that it is a means to create distinctive and sustainable value-adding capabilities, more easily defensible from competition based in lower cost economies (Tian et al, 2012).

The shift of manufacturing companies from product-focused to service-focused business models has been labelled with interchangeable terms such as “servitisation”, “product-service systems”, “integrated solutions”, “service infusion”, “tertiarisation” (Lay et al 2010), “servicizing”, “service enhancement”, “service factory” (Tian et al, 2012) and “eco-efficient services” (Goedkoop et al, 1999). There is evidence of an increasing service intensity in the European manufacturing sectors since, at least, the mid-1990s (Falk and Peng, 2013).

In the area of chemicals, service-focused business models have been evolving since the late 1980s, including reference to Chemical Management Services (CMS) and to Chemical Leasing (ChL).

One of the first companies to pioneer these concepts was General Motors, partnering with chemical suppliers and transferring elements of overall chemical management to them on a facility-by-facility basis (Stoughton and Votta, 2003). European companies started adopting service-focused business models in the chemical area in the mid-1990s/early 2000s, although chemical manufacturers were already familiar with the concepts (Mont et al, 2006).

Stoughton and Votta (2003) define CMS 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*”. The CMS concept covers both the provision of services together with selling chemicals and the provision of system solutions in which the chemical providers take over the management, use and disposal of chemicals from customers’ processes (Reiskin et al, 2000).

Chemical Leasing is instead defined as “*a service-oriented business model that shifts the focus from increasing sales volume of chemicals, toward a value-added approach. The producer mainly sells the functions performed by the chemical, and functional units are the main basis for payment. Within chemical leasing business models, the responsibility of the producer and service provider is extended and may include the management of the entire life cycle. Chemical leasing strives for a win-win situation. It aims to increase the efficient use of chemicals while reducing the risks of chemicals, and protecting human health. It improves the economic and environmental performance of participating companies, and enhances their*

access to new markets. Key elements of successful chemical leasing business models are proper benefit sharing, high-quality standards and mutual trust between participating companies” (UNIDO, 2011).

ChL and CMS are often seen as similar concepts and, in some cases, they might have common features and overlapping scope. Reniers et al (2013) suggest that the main difference between the two concepts is that the compensation mechanism in ChL is always based on the chemical services delivered and not on chemical volume sold, while in CMS the supplier, usually, is not paid on the basis of the function of the substances. Stoughton and Votta (2003) agree that such a compensation mechanism in CMS occurs only under a mature, full-service programme and that CMS, in practice, “*covers a spectrum of service levels from procurement only to comprehensive coverage across the chemical lifecycle*”. They maintain that recurring to an outside chemical service provider is the defining element of CMS, but that “*the exact scope and compensation mechanisms within a CMS program play a critical role in realizing the potential environmental benefits of the model*”. CMS business models with the provider's compensation being tied primarily to quantity and quality of services delivered instead of chemical volume have been promoted by the Chemical Strategies Partnership¹ in the US since 1996 (e.g. White, 2001; Kauffman Johnson, 2004).

At times, ChL is perceived as requiring a transfer of liability. For example, according to Stoughton and Votta (2003), the main difference between the two concepts is the transfer of liability from user to supplier that the term ‘leasing’ implies, which is not possible in the US regulatory context. Reniers et al (2013) agree that ChL implies a liability transfer from user to supplier in a lot of cases. However, since the liability transfer does not occur in all the cases and is not an obligatory feature of ChL, it cannot be considered a defining element.

Beyond these differences, all European and US researchers agree that it is the change in the supplier compensation from volume of product supplied to quality/quantity of services provided that realigns the incentives in the supplier-user relationship and that allows achieving the potential economic and environmental gains.

ChL, as it is currently defined and adopted by UNIDO, has been paired with the five sustainability criteria developed by the German Federal Environment Agency (UBA) on the basis of eight pilot-projects carried out in Germany (BiPRO, 2010):

- Reduction of adverse impacts for environment, health, energy and resource consumption caused by chemicals and their application and production processes;
- Improved handling and storage of chemicals to prevent and minimize risks;
- No substitution of chemicals by substances with a higher risk;
- Economic and social benefits are generated; a contract should contain the objective of continuous improvements and should enable a fair and transparent sharing of the benefits between the partners; and
- Monitoring of the improvements needs to be possible.

The criteria aim to ensure that the minimisation of risks to the human health and the environment is always present as an objective of the implementation of the model, and also to facilitate possible public

¹ <http://www.chemicalstrategies.org/about.php>

support, to enhance the communication of objectives and results and to improve the co-operation of the parties.

For the purpose of presenting the economic features of the ChL model, literature referring to both ChL and CMS was reviewed and the analysis of the CMS model was reported when the findings apply to the ChL model as well.

1.2 Study Objectives

The general objective of this study is to analyse the economic features of the ChL business model and, if appropriate, to suggest potential policy measures to promote the efficient application of the model.

More precisely, the specific objectives are:

1. To describe the main stakeholders involved in the contract and in the implementation of the model, their role and interaction;
2. To identify and describe the main market and policy drivers that support the development of the model;
3. To describe the functioning of the ChL model and to provide a comparative analysis with “ordinary contracts”, including liability aspects. In particular, this study looks into how ChL contracts manage the potential for opportunistic behaviour due to information asymmetry between the parties;
4. To describe the main costs and benefits of ChL for consumers, producers/providers and for society and the environment. In particular, the study aims to provide answers to the following questions:
 - Is there really an incentive to transfer know-how from the supplier to the user?
 - Are the contracts set up under chemical leasing necessarily long term contracts? If yes how long, on average, is the user engaged with the supplier?
 - What are the economic costs of chemical leasing? Are these costs different across industries? What do these costs depend on?
 - What are the observed and predicted market failures? Is it only about information asymmetry? Is there risk of formation of monopolies on the supply side if chemical leasing was strongly promoted?
 - Are policymakers able to address these market failures in an efficient way (in terms of time and money)?
 - Do these market failures differ across industries/firms? Could ChL be promoted by policymakers only in some cases, where the expected benefits significantly outweigh costs?

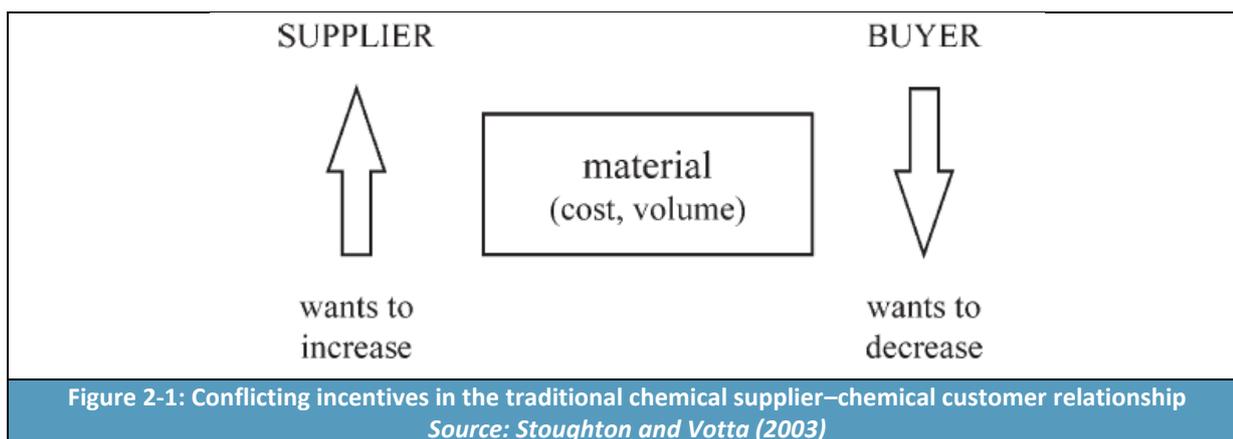
THE CHEMICAL LEASING BUSINESS MODEL AND ITS MAIN STAKEHOLDERS

2.1 The Chemical Leasing Business Model

In 2002, the Austrian Ministry of Environment launched two studies to investigate the potential of ChL and subsequently implemented some first concrete projects. In 2003, in face of the promising results, UNIDO integrated ChL in their project portfolio, as a means to support and promote sustainability in the chemical industry. Germany and Switzerland, respectively in 2006 and 2010, joined Austria in offering direct financial support to the UNIDO initiative on ChL and in actively contributing to its further development (UNIDO, 2016). In November 2016, UNIDO and the governments of Austria, Germany and Switzerland have signed a Joint Declaration of Intent on Chemical Leasing to increase awareness on the business model and foster its adoption by companies.²

The ChL concept is seen as part of the wider concept of Cleaner Production (CP), namely an integrated preventive environmental strategy to increase resource efficiency and reduce risks to humans and the environment. The CP concept was developed at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992 (Schwager, 2008). At the 2002 Johannesburg World Summit on Sustainable Development, the commitment to cleaner production was renewed and, as a consequence, the Strategic Approach to International Chemicals Management (SAICM) was agreed and signed in Dubai in 2006. At a side event of the Dubai International Conference on Chemicals Management, UNIDO presented the ChL concept to the international community (Joas, 2008).

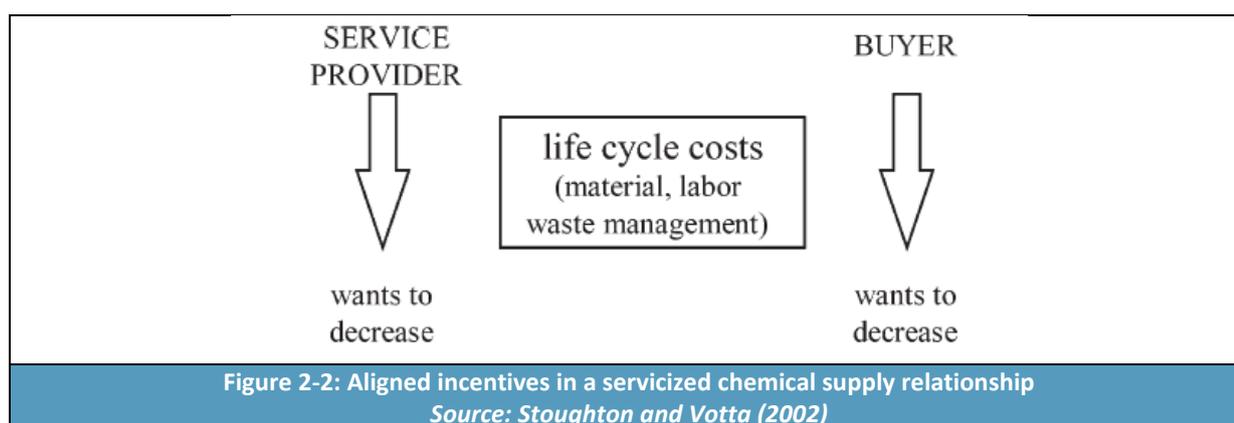
The ChL concept stems from the idea of reversing the fundamental economic relationship between chemical supplier and chemical customer which, as noted by Stoughton and Votta (2003), creates supply side incentives for increased chemical use (Figure 2-1).



² <http://www.unido.org/news/press/joint-declaration-of.html>

Moreover, the volume-based discounting offered in any traditional selling contract is problematic from an environmental perspective, as the chemical supplier aims to exchange larger volumes of goods and the buyer may not have adequate incentives to improve the efficiency of the process in which the chemical is used.

In the ChL model, the chemical supplier is compensated on the basis of the services delivered, instead of the volumes of chemicals sold. In this configuration, the chemical supplier and the chemical user enter in a strategic partnership, with the common goal of reducing chemical consumption (Figure 2-2). Both the provider's and customer's incentives are aligned and can achieve benefits from improved performance, chemical handling and waste management.



An example can better illustrate how the environmentally perverse incentives of a traditional business model can be transformed by a service-based model: a manufacturer of brass instruments has to silver plate 20 trumpets a day. One litre of silver cyanide solution (a highly hazardous substance) can finish 5 trumpets; therefore, the manufacturer needs to purchase 4 litres of silver cyanide a day, assuming no spills, accidents or over-application. After silver-plating, each instrument needs to be rinsed thoroughly using 5 litres of water. If the silver cyanide solution costs €50 per litre, the manufacturer pays the supplier €200 for the solution, while simultaneously incurring the wastewater management costs (if the cost is €1 per litre of wastewater, he pays €100) and additional hidden and indirect costs of managing the substance at each life cycle stage (inventory, transport, storage). The supplier earns a profit of €200 and sees additional sales from every problem that results in an increased use of the solution. Though the supplier may advise the customer on how to better use its product, it does not have interest in seeking a higher efficiency in the process of the customer.

In a ChL model, the chemical supplier is compensated on the basis of chemical services delivered, not on chemical volume sold, aligning the economic incentives of both contractual parties towards reduced chemical consumption. This is possible because the application of the chemical is not the core competence, nor the core business, of the trumpet manufacturer. If the chemical supplier can ensure that the function of the chemical (silver plating) is delivered by managing the handling and use of the substance in the manufacturing plant, then a move to a ChL model is possible. In this case, the supplier is compensated on the basis of each silver plated trumpet. If, as a baseline, it costs the supplier €15 for each silver plated trumpet (€10 for silver plating and €5 for the wastewater management) and he receives €25, the supplier still makes a profit of €200, but the incentives with respect to chemical consumption are completely reversed. Instead of profiting more by an increase in use of silver cyanide solution, the supplier stands to gain more by decreasing the chemical use. If the supplier increases the process efficiency and reduces the amount of solution required for each trumpet by 50%, the supplier only needs 2 litres of solution to silver plating 20 trumpets and 50 litres of water to rinse them. His costs are reduced to €150 (or €7.5 per trumpet) and his profits grown by 75% (from €200 to €350). The supplier now has an incentive to

work with the manufacturer to seek more efficient ways to silver plating the trumpets and even to search for alternative less-hazardous chemicals, such as non-cyanide silver solutions. Moreover, under a gain-sharing arrangement, as required by a ChL contract, savings are shared to further incentivise both buyer and supplier.

The switch to a compensation mechanism based on the service delivered rather than the chemical volume sold is possible, in particular, when the subject of the traditional contract is chemicals for indirect use or, as called by Mont et al (2006), secondary chemicals. These are chemicals that are not used in the final product, but are instead used, for example, to oil and clean the machines. According to Lozano, Carpenter, Lozano (2014), “*the types of chemicals that are covered by the concept are non-reactant products that are easy to recover and have a high recovery rate (more than 75%), 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*”. OECD (2004) notes that the applicability of ChL is subject to some restrictions: it should be possible to define the application of the substance as a service (e.g. cleaning, dissolving, reacting) and the substance should be used in a closed system.

Although ChL has been mostly applied to chemicals with the above characteristics, there are notable exceptions to these restrictions: paints and coating chemicals, for example, become part of the final product. Moreover, ChL is evolving and the model has been successfully applied to pesticides too. Ultimately, ChL is especially useful in those areas where chemicals are used outside of the core expertise or competence of the user. Table 2-1 presents the industrial sectors and types of chemicals to which ChL has been applied and provide examples of the bases of payment used for the contract.

Table 2-1: ChL applications across sectors		
Industrial sectors	Chemicals identified	Basis of payment for the ChL contract (examples)
Manufacture of electronic equipment	Powder coatings	USD/m ² of powder coated area
Manufacture of fabricated metal products (e.g. cars, food processing equipment)	Organic solvents, detergents	USD/Vehicle produced
Various industries/steal treatment	Galvanising and phosphating agents	USD/Ampere-hour
Beverage production	Lubricants for packaging conveyors	USD/Number of working hours of the conveyor
Waste water and drinking water treatment	Water treatment chemicals	USD/m ³ of purified water
Accommodation and service sector	Cleaning chemicals	Combination of 3 elements: kg of laundry; meals served and m ² carpet area (floor and rooms)
Beverage and food processing	Glues, adhesives, detergents, sanitising chemicals	USD/ number of bonded boxes
Petrochemical industry	Catalysts and water treatment chemicals	USD/Kbbl of oil with a specified quantity
Printing industry	Ink, printing chemicals	USD/Number of printed copies of the newspaper
Agriculture	Pesticides	USD/Potatoes harvested per season (yield)

Source: reproduced from UNIDO (2013)

To further clarify the functioning of ChL, the main stakeholders involved in the actual implementation of the concept and the different possible models of interaction are introduced.

Chemical suppliers (producers and distributors)

A prerequisite for chemical suppliers to be involved in ChL is the possession of expertise relating to the efficient and effective use of the chemical substances they produce and sell. If this is the case, the role of chemical suppliers within a ChL model shifts from being a pure provider of a product towards being a service provider. Suppliers become responsible for the provision, use, and sometimes disposal, of the chemicals and are paid for these services per functional unit. This service-based unit of payment generates an interest among the business partners to optimise the use of chemicals and achieve increased efficiency, reducing the amount of chemicals necessary for a certain result. In this way, suppliers are rewarded for their expertise and have an incentive to fully inform the users on the properties and optimised use of the traded chemicals.

Another important aspect of ChL is the increased sustainability of the relationship between suppliers and users of chemicals. Under traditional business models, users can quickly switch to another supplier who offers better prices on the globalised market. Due to the close cooperation between the business partners under ChL, the importance of the absolute price of chemicals declines in favour of quality and efficient use. Furthermore, users can inform their suppliers about potential changes in their production at an early stage in order to involve the supplier in finding an optimal solution, resulting in long and trustful cooperation. Thus, the supplier faces less competition and more stable business relationships.

ChL may also generate a demand for more efficient chemicals. Such chemicals are often connected to higher prices and therefore rarely applied under traditional business models. ChL partnerships can justify the use of those chemicals due to the increased efficiency, optimisation, and reduced quantities which still enables ChL partners to generate economic benefits and suppliers profit from their research and development of improved chemical substances.

Chemical users

ChL constitutes an interesting business model for chemical users whose core competence is not necessarily based on an optimised use of the chemicals they buy. Under ChL, users benefit from the supplier's expertise and can thus optimise processes and reduce the amount of chemicals used. Since they only pay for the service rendered by the chemical, the proportion of the user's costs related to the chemical decreases if processes are optimised.

In most cases, chemical users are no longer responsible for the disposal of the used chemicals as suppliers take back their substances. In these cases, this leads to more or improved recycling of chemicals and the users can focus on their core competence.

The improved handling of chemicals due to advanced knowledge, the reduction of chemical consumption, and the application of less hazardous alternatives that (may) accompany ChL lead to risk reduction at workplaces and decreasing exposure of workers. This in turn results in an enhanced overall environmental and occupational health and safety (OHS) performance of chemical users.

Equipment suppliers

Equipment suppliers become involved in a ChL contract to provide the necessary technology for optimising processes. A close collaboration between the chemical supplier, the user, and the equipment supplier can generate innovation with new or improved equipment and processes. The benefits for equipment suppliers result from the access to new markets due to innovations and further development of their equipment. Moreover, equipment suppliers that already have advanced but costly technologies may now be able to introduce these technologies to the market, as efficient and innovative equipment may be required for process optimisations under ChL. According to the fourth quality criterion of the ChL concept, a contract should contain the objective of continuous improvements: parties have therefore the incentive to pursue the adoption of best available technologies, with the leasing model ensuring the distribution of costs over time while benefiting from the improvements from day one.

Recycling and waste management companies

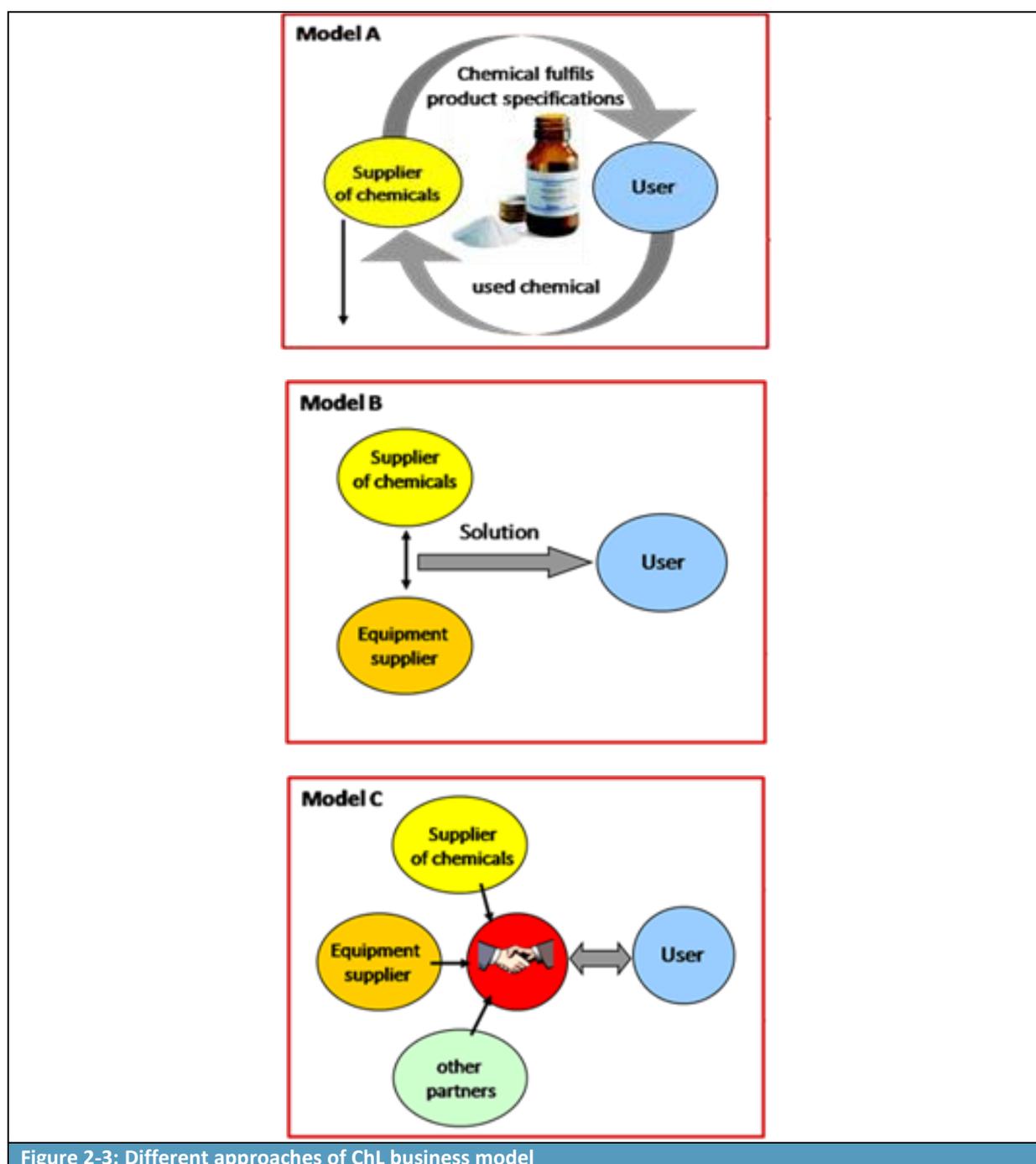
Through ChL there is a direct interaction between recycling companies, suppliers and users of chemicals. Recycling companies will provide expertise for proper recycling possibilities and waste management of the chemicals. The provision of this knowledge leads to optimised recovery and recycling and is rewarded through the company's integration of recycled chemicals into the ChL business model, contributing to develop a more circular economy.

Models of Interaction

There are three elementary models of interaction between the parties (Joas, 2008):

- **Model A** involves the least complex constellation, namely a supplier and user of chemicals. Both partners optimize chemical use and try to close the material flow as far as possible. According to the principle of Chemical Leasing, the user pays for the benefit of the chemical. This model is often chosen for implementation projects on a short-term basis.
- **Model B** is of higher complexity as it brings three parties to the project, integrating an equipment/plant supplier along with user and supplier of chemicals. Chemicals supplier and equipment producer cooperate to improve the efficiency of the products. The user pays for the complete solution and further optimizes it together with the two other partners.
- **Model C** exhibits the highest degree of complexity with the interest of all partners bundled in a structural setup that can take the form of a joint venture, consortium or new company. The focus of such a constellation is long-term and the user has usually one responsible partner and pays for the complete solution. An example for the need of such a model might be the inability of a supplier to accept waste for recycling and therefore an additional partner, such as a recycling company, might become necessary.

The three models of interaction are sketched in Figure 2-3.



Other stakeholders involved in the development, advancement and dissemination of ChL

The international community and national and regional public authorities

In Europe, the first public authority to realise the potential of ChL in enhancing the environmental record of chemical manufacturers and users has been the Austrian Federal Ministry of Agriculture,

Forestry, Environment and Water Management that partnered with UNIDO to pioneer the ChL concept since 2004 with the direct support of the Austrian, and later the German and Swiss governments.

At global level, UNIDO is playing a critical role in promoting ChL as a way to contribute to sustainability goals in the management of chemicals. It is providing support in the implementation of the model to companies in developed but also in emerging and in-transition countries. Through its National Cleaner Production Centres (NCPCs) UNIDO provides support on the implementation of the business model to companies, in particular those in emerging economies. This involves, amongst other things, awareness-raising as well as the provision of practical experiences and support during the implementation phase. Furthermore, the NCPCs act as moderators e.g. during contract negotiations and are in some cases responsible for the monitoring of the progress of a ChL project. This is explicitly agreed upon in the contract.

Public authorities in OECD countries but also partner economies may see ChL as a potential way to reinforce the sound management of chemicals, enhance resource efficiency, support the development of a circular economy as well as mitigating climate change.

Industry associations

Industry associations have strong and well-established relationships with their member companies and possess an excellent overview of their specialised sector. They are in a very good position to identify where ChL could become an opportunity for a specific industry or value chain.

For example, the European Chemical Industry Council (Cefic) (Cefic, 2017) is not new to the concept and has recently called for the European policymakers to consider how the current European Commission's circular economy strategy (EC, 2015) can be implemented in order to best enable the uptake of the ChL model (Cefic, 2015). Cefic has recently recognised the SAFECHEM ChL business model with the Responsible Care Award 2016³.

Another example is the European Solvent Recycler Group, that already in 2004, prior to the implementation of the REACH Regulation (EU, 2006) and of the Waste Framework Directive (EU, 2008), called for the European authorities to ensure that the new legislations would not hamper the implementation of service-oriented business models.⁴

Research and academic institutes

ChL brings along several possibilities for research activities to advance the business model concept from a scientific perspective and raise awareness among the scientific community. Research activities in the field of ChL that can be conducted by universities/research institutes or public private partnerships and can cover numerous fields such as: substitution of hazardous chemicals and development of sustainable alternatives; innovative technologies and process optimisation (new processes, recovery of chemicals, measurement and control technology, monitoring systems, etc.); economic effects and implications of ChL and its financial mechanisms, etc. The research activities that eventually lead to publications of scientific papers raise awareness, provide innovative ideas, and may stimulate interest in and uptake of ChL at company level.

³ See more information at <http://www.cefic.org/newsroom/top-story/Cefic-Unveils-Responsible-Care-Industry-Award-Winners/>

⁴ See for example, ESRG-Declaration on REACH and solvent recycling, available at <http://esrg.de/pages/statements/reach-and-solvent-recycling.php>

POTENTIAL MARKET OF CHL AND EXAMPLES OF PRACTICAL IMPLEMENTATION

3.1 Past Applications and Potential Market

In the United States, total CMS has been mostly developed in the automotive, electronics, aerospace and metalworking sectors (Stoughton and Votta, 2003), leading to a number of successful stories in terms of better compliance to regulation, increased competitiveness, safer working conditions, better environmental records and significant cost savings. Already in 1998, the estimated penetration of CMS in those sectors varied between 5-15% in the aerospace manufacturing industry to 50-80% in the automotive industry (CMS Industry Report, 2000).

In Europe, total CMS with the compensation mechanism tied to the service delivered instead of the chemical volume sold were first provided by paint manufacturers to the automotive sector. Mont (2006) provides the example of Dupont, which has been managing Volvo's paint workshop and has been paid per unit painted area since the mid-1990s. From around the turn of the century, the large international chemical companies started adding information management and technical services such as process development, chemical application and waste management to their chemicals business, becoming CMS providers. Other examples of total CMS providers for the automobile and aerospace industries are PPG to Opel, Castrol to Airbus, Quaker Chemical Corporation to Toyota and BASF to several automobile facilities (OECD, 2004).⁵ With regard to total CMS users, in Europe, these are the large multinationals in automotive, metalworking, electronics and aerospace. Among the companies listed in the literature are: ABB, Airbus, Carlsberg Sweden, Daimler Chrysler, Eriksson, Ford, Micron Technologies, Motorola, SAAB, STMicroelectronics, Toyota, Volkswagen and Volvo Penta (Mont et al, 2006).

With regard to ChL, over the past ten years, the model has been successfully implemented in numerous countries and sectors. It has been implemented in Europe and in the United States, where chemical service has already been in use for the past decades. UNIDO is supporting the development of the model in a large range of sectors in emerging and in-transition countries. There is no exact number regarding the scale of implementation of ChL. A study on behalf of the German Federal Environment Agency estimates that more than 400 ChL contracts exist in Germany, mainly for the cleaning of pipes and vessels in the food industry and for the use of abrasives in the metal industry (UBA, 2015).

ChL has been mainly applied to specialty chemicals (dyes and pigments, crop protection, paints and inks, auxiliaries for industry) and, in Europe, its potential market is of around 30% of the total chemical sales (Table 3-1). However, some barriers need to be overcome in order for the model to aim for such market penetration. These are discussed in Section 4.4. In the following subsection, some examples of successful implementation of ChL are presented.

⁵ Other companies providing total CMS that are listed in the literature are: AB Svenska Shell, Ashland Speciality Chemicals Limited, BASF, Castrol (Singhal, 2003), Akzo Nobel (UNIDO, 2016), BetzDearborn (Bierma and Waterstraat, 2000), Cimcool Europe, Comau Ingest AB, Dow, Dupont, FPF - Fujitsu MM, Fuji Hunt Photographic Chemicals NV, Henkel Technologies, Malco, Quaker, PPG, Rockwood, Shell Services, Kemira Kemi and AGA (Mont et al, 2006).

Chemical sub-sectors	Sales - € billion	Sales - Share
1. Petrochemicals	149.2	27.1%
2. Basic Inorganics	69.3	12.6%
Other inorganics	29.9	5.4%
Industrial gases	14.7	2.7%
Fertilizers	24.7	4.5%
3. Polymers	109.9	19.9%
Plastics	91.8	16.7%
Synthetic rubber	11.8	2.1%
Man-made fibres	6.3	1.1%
4. Specialty chemicals	152.9	27.8%
Dyes & pigments	11.6	2.1%
Crop protection	10.7	1.9%
Paints & inks	42.7	7.8%
Auxiliaries for industry	88.0	16.0%
5. Consumer chemicals	69.6	12.6%
Chemicals excluding pharmaceuticals	551.0	100.0%
<i>Source: Cefic (2016)</i>		

3.2 Examples of Application of Chemical Leasing

3.2.1 Metal cleaning – Austria/Germany

Erbel (2008) presents a best practice example of ChL in metal cleaning in the automotive industry. The main business partners were:

- PERO AG, a medium sized, family-owned company based in Germany, with over 200 employees, producing high tech cleaning machines for many different industries such as automotive, aerospace, jewellery, watches, lighting, electrical and optical industries;
- SAFECHEM Umwelt Service GmbH (part of the DOW Group), a provider of services and solutions related to the safe and sustainable use of solvents for surface and dry cleaning applications. For a fixed monthly fee, the company offers its customers the ability to lease solvents and degreasing equipment, combining this with customised chemical services, including the delivery of solvents and direct comprehensive support services that include waste management, technical support/training, and the use of high quality stabilisers, additives, and test-kits.

SAFECHEM and PERO AG established a joint venture, PERO Innovative Services GmbH⁶, as a centre of excellence for metal cleaning in Austria. The first client to sign a chemical leasing contract with PERO Innovative Services was the company Automobiltechnik Blau, whose core competence is the production of metal parts for the automotive industry. Thanks to the co-operation among the business partners, an innovative and highly efficient technology has been applied to clean the metal parts, characterised by low consumption of energy and low usage of chemicals. Automobiltechnik Blau provided the quality specification for each individual part and paid per number of cleaned parts.

The main advantages for the client were that they did not have to make any initial investment while receiving a reliable and more efficient process without the need for in-house experts. Moreover, the supplier satisfied all legal formalities with regard to health and safety and environmental regulations.

⁶ <http://www.pero.ag/en/startseite.html>

Automobiltechnik Blau could therefore focus on its core competence. It should be noted that the cleaning process was carried out not at the client's premises but at a third location that was found with the help of Automobiltechnik Blau (OECD, 2004).

Since PERO was both the equipment and service provider, they were not incentivised to purchase cheaper machines with sub-optimal performances; instead, a high performance machine was installed for the process. The solvents and stabilisers adopted were selected by SAFECEM according to the specific needs of the client, and the joint venture was able to look after the supply, reconditioning, recovery and maintenance of the chemicals.

According to Erbel (2008), in 23 months (from May 2005 to March 2007), the following cost reductions were achieved:

- Energy: reduced by 50.1%;
- Spare parts and services: reduced by 66.4%;
- Solvents: reduced by 71.7%;
- Stabilisers: reduced by 76.9% and 55%, respectively.

SAFECEM has established its own trademark for ChL and is actively supporting the business model. For different projects the company was honoured at the Global Chemical Leasing Award in 2012 and 2014 and has won the European Responsible Care Award 2016 across all categories⁷.

3.2.2 Water purification – Russia

Startsev A and Schott R (2008) present the implementation of a ChL contract in the wastewater treatment sector in Russia.

The main business partners were:

- ERG, a small enterprise specialising in wastewater purification for different industrial branches, which was the ChL service provider, covering the supply of chemicals, equipment, personnel training and residual waste disposal;
- Henkel-ERA, producer of industrial and household glues, synthetic soaps and detergents, and user of the wastewater purification service.

Due to an increase in glues production, Henkel-ERA was no longer able to achieve the level of water decontamination required and needed to find an alternative solution. Together with ERG, that was supplying chemicals and materials for the wastewater treatment, they decided to implement a ChL model. This led to both companies being motivated to co-operate to achieve better environmental results.

ERG installed an improved wastewater purification facility at the client's premises and leased the required chemicals. Moreover, it took care of the user's personnel training and of the residual solid waste transportation and disposal. Henkel-ERA carried out all the activities necessary for the installation of the new treatment facility and agreed to pay ERG on the amount of purified water (cubic meters). The

⁷ <http://www.dow.com/safechem/eu/en/pdfs/SAFECEM-Wins-Responsible-Care-Award-for-Chemical-Leasing.pdf>

treatment costs were reduced by around 50% (from €27 to €13 per cubic meter), due to a decrease in chemicals consumption, and the decrease of emissions of organic compounds to the environment (water) was up to 98%.

The North-Western International Cleaner Production Centre co-ordinated and facilitated the agreement between the parties.

3.2.3 Well drilling

Since 1997, Cabot Specialty Fluids (CSF) started leasing cesium formate brines to oil companies for their well drilling activities around the world⁸. Among CSF's clients are: Statoil, Shell, BP, ExxonMobil, ENI and Total.

CSF remains owner and manager of the chemicals and charges their clients for the number of days the chemicals are used in the field. Through their expert management, CSF is able to reduce the overall consumption of raw materials, energy and water, and to minimise waste, recovering around 80-85% of the brine.

CSF was awarded with the ChL award by UNIDO in 2011.

3.2.4 Car coating – Poland

PPG Industries is a global supplier of coatings, glass, fibre glass and chemicals and is the world leader in transportation coatings. The company offers different chemical management services (from logistics and warehouse to process management and quality control) to automotive companies across the world (among the clients: Volkswagen, Renault, Opel, Mercedes, GM, Aston Martin, Fiat).

In the Opel factory in Poland, PPG took over the management of all chemical materials, not only of indirect chemicals but also of chemicals used on product vehicles, to optimise the process and reduce environmental impacts (OECD, 2004). PPG has a large team of personnel working at Opel's factory and the team deals with all sub-suppliers (around 50 for 700 products) and manages all applications of chemicals for coating. This leaves Opel able to focus on their core competence and has led to a 30% increase in resource efficiency, with the percentage of "right first time" in the paint shop passing from 50% to 95%. Chloride concentration in wastewater has been reduced by 70% and there has been a reduction in wastewater sludge too. The resulting cost savings for the customer have been around €100,000 per month⁹.

3.2.5 Brazil

A recent success story of implementation of ChL is the case of cleaning services in the hotel sector in Brazil. The company Ecolab and the Windsor Hotel in Rio de Janeiro established a ChL project aiming at the reduction of cleaning agents used in the hotel. Specifically, ChL is applied for laundry services (washing of towels, linen, employees' uniforms), cleaning operations in bedrooms, bathrooms, and common areas, and for dishwashers (cleaning of cutlery, dishes, and glasses). Windsor pays Ecolab per occupied room in exchange for the service provision. Ecolab controls the quantities of chemicals and takes care of the proper handling, which also includes the training of employees [Kawa 2014]. The benefits reported by the business partners include an 80% decrease in chemical consumption, reduced exposure of

⁸ Formate Matters – News and opinion from Cabot Specialty Fluids. Issue no. 6 – December 2010/January 2011. "Cabot honoured with UNIDO chemical leasing award".

⁹ Presentation of PPG Chemical Management System by Kazimierz Miga and Andy Benson. Available at: http://www.umweltbundesamt.at/fileadmin/site/umweltthemen/chemikalien/CL_Miga_Benson.pdf

workers to chemicals and fewer accidents, cost reductions for the hotel and better budget planning for both companies. Other benefits include better education of the employees in the use of chemicals, which increases their awareness for environmental and health issues. A recent study on behalf of UNIDO assessed that the reduction in chemicals saves about 10 t of greenhouse gas emissions and 7300 m³ water per year [UNIDO 2015a].

3.2.6 Serbia

In Serbia, the confectionary producer Bambi is applying ChL for the bonding of boxes. Henkel is supplying the adhesives and optimised the packaging process. Optimisations have led to the substitution of the old adhesive with a more efficient (but not more hazardous) one. This caused a reduction in application temperature by 30 °C (almost 20 %) and pressure by 1.1 bar (almost 38 %). Economic benefits for Bambi result from reduced costs for energy, maintenance, cleaning, and adhesives due to decreased consumption of 30 to 40 %. Furthermore, less waste is generated (adhesives and packaging). Higher productivity was an additional side effect due to fewer maintenance requirements, e.g. for the changing of nozzles and hoses. A gained benefit for the workers is the automatic dosing of the adhesive that better prevents accidents. The unit of payment is the number of bonded boxes.

3.2.7 Uganda

The company Crown Beverages Ltd. in Uganda established a ChL contract with Diversey Eastern and Central Africa for conveyor lubrication and the cleaning of glass bottles for soft drinks, which requires several steps. Instead of buying the lubricant and several detergents, Crown Beverages now pays for these services per litre of beverage produced. ChL resulted in tremendous improvements of the processes and generated direct cost savings of almost US\$ 175 000 within six months. Lubricants were reduced by 44 % and water consumption decreased by 5 %. Approximately 875 000 t of CO₂ emissions have been prevented through the ChL implementation within six months. Moreover, the company's employees receive training for optimal use and chemicals are handled in a safe way.

COSTS AND BENEFITS, DRIVERS AND BARRIERS

4.1 Introduction

This chapter provides an overview of major policy and market drivers involved in the uptake of ChL by industry as well as the barriers to a wider adoption of the model. It also highlights the expected costs and benefits of the implementation of the model.

4.2 Policy Drivers

Environmental and health and safety legislation, in particular chemical policy, is the most important driver for the uptake of the ChL model. For example, in the European Union the REACH Regulation requires close communication of information through the supply chain and may incentivise the adoption of ChL. It is however its synergy with the other pieces of European environmental legislation (such as the Water Framework Directive or the Industrial Emission Directive) that provides the strongest push towards service-focused business models.

Besides the European Union, other countries have established sophisticated chemicals legislative frameworks: examples are the Australian Industrial Chemicals Notification and Assessment Act, the Canadian Chemicals Management Plan, the Toxic Substance Control Act in the US, the New Hazardous Substances and New Organisms Act in New Zealand and the Japanese Chemical Substances Control Law. Others are planning or in the process of enhancing their chemicals risk assessment procedures. All these efforts have the common objective of providing more information to the public and to further involve the chemical industry in reducing the use of hazardous chemicals (OECD, 2015).

Compliance with chemical policy requires constant innovation at the chemical substance level (search for safer alternatives), at the technical process level (search for more efficient processes and technologies) and at organisational level (search for new business solutions).

Besides, through the request of (eco)toxicological information for chemical substances and the exchange of information through the supply chain and the restriction of chemicals of concern, authorities can support the implementation of ChL through other market instruments, such as public procurement, taxes (e.g. reduction of the VAT rate) or the provision of research funds. They can also increase awareness of the availability of such business models among prospective users, in particular small and medium sized enterprises, and provide support for their adoption (in the form of information and training provision or environmental tax waiver).

4.3 Market Drivers and Benefits

The current global market is characterised by increased international competition and by declining margins. These two main features make the adoption of ChL attractive, as a way of improving the competitive position of chemical producers by introducing a broad range of value-added products and services that help in achieving greater efficiency, in maintaining solid relationships between chemical suppliers and customers and in avoiding price underbidding.

Moreover, the increase in the demand for greener consumer products may push large retailers to require higher environmental standards of their suppliers, driving the uptake of innovative business models.

For those companies for which chemicals-related activities are not part of the core business, the attractiveness of ChL lies on the possibility that a chemical service provider may be able to accomplish the chemical management tasks more cheaply than they can be performed in-house (Stoughton and Votta, 2003). In this case, ChL may deliver some of the specific benefits listed below:

- Benefits increasing the competitiveness of the user:
 - Direct cost savings (reduction of chemical quantities if processes are further optimised)
 - Indirect cost savings (via energy, waste management)
 - Access to better knowledge – improvement of processes and reduction of risks
 - Reliable, long-term business relationships
- Benefits increasing the competitiveness of the supplier:
 - Higher profits (monetary reward for supply of expertise and services)
 - Reduced costs for raw materials
 - Reliable, long-term business relationships
 - Access to knowledge regarding application of chemicals, first-hand experience concerning areas for improvement/innovation of substances

Via the close collaboration and shared expertise between the users and the suppliers (as well as other partners), ChL may induce innovation and can lead to the development of advanced processes, substances or technologies. Potential areas for innovation include: i) substitution of hazardous substances with less hazardous ones due to improved or altered processes; ii) more efficient processes are developed that necessitate fewer chemicals, iii) new equipment is developed that enables alternative or more efficient processes, and iv) new service offerings or packages in the form of, for example, joint ventures between different supply chain actors.

Proper waste management of chemical substances presents a burden to some chemical users as it may generate additional efforts, costs and legal obligations. ChL may cover the management of the chemical waste stage, thus reducing the responsibility for the chemical user. Suppliers may have more knowledge about the proper recycling or disposal of the chemicals and manage the used substances in an environmentally sound manner.

In order to realise the aforementioned benefits however, an adequate compensation scheme needs to be implemented. The supplier profit must be decoupled from chemical volume, via a flat inclusive price per unit produced or gain sharing mechanisms. Compensation mechanisms based on passing the chemical purchase costs from the chemical user to the chemical service provider combined with a volume-based management fee are the least likely to realise environmental benefits because it does not decouple the supplier profit from chemical volume. An alternative compensation mechanism that is very effective in realising environmental benefits is a flat per-unit fee. However, this may only be appropriate under certain conditions, i.e. where there is a constant production volume of the same product. Failing flat per-unit fees, gain-sharing mechanisms between service supplier and service user are essential. With this compensation mechanism, cost savings obtained through improvements in efficiency and reductions in the use of chemical substances are shared among the parties (Stoughton and Votta, 2003).

4.4 Costs and Barriers

The literature identifies key areas where transformation challenges are experienced by those engaged in a process of servitisation: strategy, organisation, enterprise management, contracting, culture and operations (Vandermerwe and Rada, 1998; Oliva and Kallenberg, 2003; Poirer, 2004; Baines et al, 2009; Ng et al, 2011).

In 2009, the results of a survey of 1,484 German companies in the manufacturing industry showed that, at the time, around 3% of the German manufacturing companies had been customers of chemical leasing (Schröter et al, 2010). Possible reasons for such a limited penetration of ChL are: strict waste legislation, lack of customer demand, liability risks, fear of losing know-how to the supplier and reluctance of the supplier to take on all the investments.

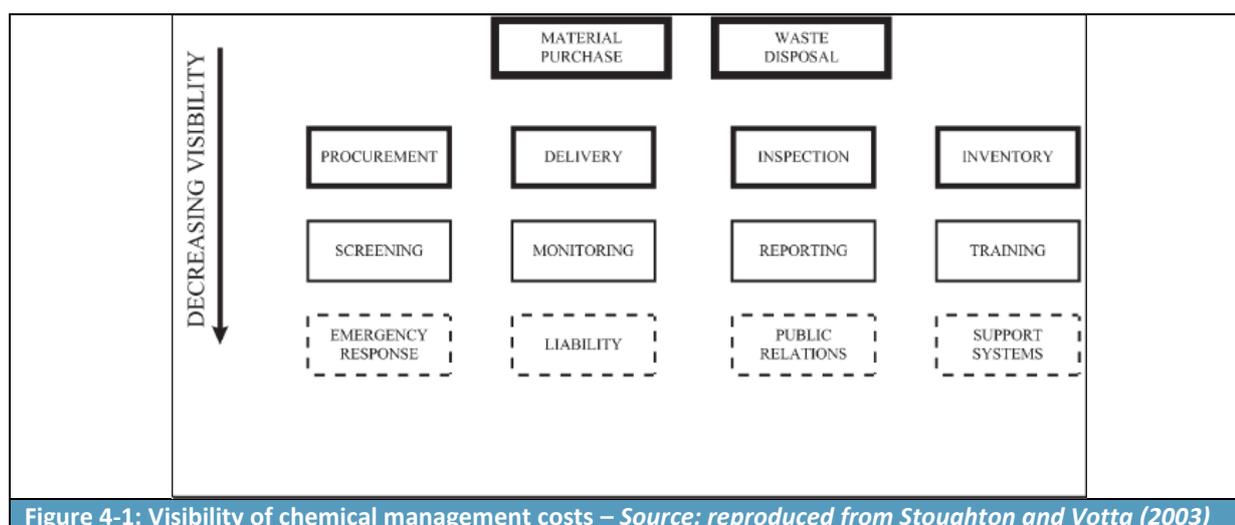
Nevertheless, in several market niches total CMS has gained major relevance. For example, it can be assumed that the majority of the cars currently produced globally have been coated through the application of total CMS by the chemical manufacturers.

As described in Lay (2014), the future relevance of CMS and ChL will increase gradually but, due to the restricted feasibility of CMS and ChL applications with regard to product groups and other factors, CMS and ChL will most likely remain business concepts of minor importance. However, it should be noted that the applicability of ChL is expanding to new chemical categories, such as pesticides.

The provision of ChL by chemical manufacturers requires quite a different set of capabilities and knowledge than the mere provision of chemicals and it often entails the development of expensive information management systems. Moreover, there may be the need for new staff, able to train the personnel of the clients and of the same ChL supplier too.

A major external barrier is that prospective CMS and ChL users are not completely aware of the life-cycle cost of chemicals¹⁰. At each stage of their life-cycle, chemicals generate costs that are higher than other material inputs, due to their specialised and heavily regulated nature. Stoughton and Votta (2003) report estimates of the ratio of chemical management costs to chemical purchase costs in the range of 5:1 to 10:1 (five to ten dollars are spent additionally to manage chemicals for each dollar of chemical purchased). These costs are characterised by decreasing visibility, as illustrated in Figure 4-1. As a consequence, companies have a poor understanding of their chemical management costs.

¹⁰ Or *total chemical costs* in Stoughton and Votta (2003).



Even when the chemical user companies have a sound appreciation of their chemical management costs and the chemical service provider has the right set of competencies, there is a business case for ChL only if two conditions are met:

- The chemical management costs can be transferred from the chemical user to the chemical service provider; and
- The chemical service provider can realise economies of scale.

When the chemical management activities are carried out by a well-defined unit in the chemical user company, the transferability is relatively easy and the potential benefits can be clearly identified. When the chemical management activities are instead performed by individual staff aside other responsibilities (and therefore constitute only a fraction of their work time), the transferability is more problematic and the chemical service provider is unlikely to be able to reduce the company direct costs, as the salaries of that staff will have to be paid anyway. As a consequence, transferability of chemical management costs may be more problematic in small-medium sized enterprises, where it is more unusual to have chemical management-dedicated staff, because of the small volumes of chemicals involved. As a rule of thumb, Stoughton and Votta (2003) report that chemical suppliers may offer total CMS (or ChL) when there are at least \$1 million of chemical sales at any given facility of the chemical user.

On the opposite side of the problem, prospective users may resist the adoption of ChL because they have already invested in in-house capacity for chemical management to ensure compliance to strict environmental and health and safety legislation. Therefore, potential ChL suppliers may find it difficult to improve the chemical management of the users.

Another obstacle, which might for example occur in the US, is that labour contracts and policies may restrict the transferability of labour and labour costs, because of liability. Stoughton and Votta (2003) recall the US liability law, where some liability associated to the use of small volumes of chemicals cannot be transferred from chemical user to chemical service provider. Moreover, ChL may be seen as a form of outsourcing and therefore unions may resist their implementation.

According to Mont et al (2006), many prospective users fear loss of knowledge about chemicals and control over those internal processes that ultimately determine the competitiveness of the company. The user's workforce may resist the idea of having external supervisors in managerial and technical positions.

Importantly, lacking any legislative restriction on certain hazardous chemicals, CMS and ChL suppliers may lack the adequate incentive to replace chemicals with safer alternatives, a process that requires consistent investments in research and development. It should be noted that in the European Union, the REACH Regulation provides such legislative incentives through the authorisation and restriction mechanisms.

There are some barriers also on the chemical supplier side: the prospect of reduced chemical sales may threaten investments and personnel in the manufacturing facilities of the company. The successful cases of CMs and ChL implementation are usually carried out by dedicated providers (with no chemical manufacturing activities) or by suppliers with an effective separation between their manufacturing and service providing departments (Stoughton and Votta, 2003).

Additional barriers to ChL (and to total CMS) come from the potential divergent views of CMS and ChL actors: their adoption relies on the existence of certain conditions, in particular, and as already mentioned, on a high level of trust between the supplier and the user. Mont et al (2006) list six different issues that hamper a wider diffusion of CMS, some of which may apply to ChL:

- ***Perception of the CMS (and ChL) market:*** CMS and ChL suppliers point to the lack of maturity and awareness of the markets¹¹ and to a certain organisational inertia by prospective users, while prospective users point to the insufficient quality of the services offered, leading to their resistance to fully integrate CMS, or ChL, into their operations;
- ***Lack of total CMS or ChL programmes:*** the provision of total CMS or ChL to a large portfolio of clients, each one with their specific chemical applications and operations, can be challenging even for large chemical companies, which may lack the necessary expertise;
- ***Information provision about chemical management costs:*** some customers pointed to the lack of transparency and detail by CMS suppliers in the life-cycle costs picture expected as a natural part of a CMS offer. Although transparency is also very important in ChL contracts, no information is available on whether this is an issue with ChL suppliers too;
- ***Liability issues:*** CMS suppliers may be reluctant to offer total CMS with a total liability transfer because potential risks depend on both their own and the customers' conduct. It should be noted that for both CMS and ChL, the liability transfer is not a prerequisite;
- ***Options if CMS or ChL is not satisfactory:*** CMS suppliers argue that it is easy for customers to change provider if they are not satisfied by the services. CMS customers point to the fact that the CMS market is not perfect and that there are only a few providers they can turn to in each application area and therefore the transaction cost of finding a new provider may be too high. Some companies reported to rely on the services of the same suppliers even after the suppliers' mistakes lead to the stop of the production processes for up to three weeks. These arguments seem valid for ChL too;
- ***Lack of environmental commitment:*** Suppliers argue that prospective CMS users lack a sufficient level of environmental commitment. Customers claim that the environmental commitment and standards of CMS suppliers are lower than their own. There is no evidence on whether this applies to ChL parties too. It should be noted that ChL, as it has been defined and implemented by UNIDO, requires a high level of environmental commitment.

¹¹ Where US markets are slightly ahead of European and other markets, due to the earlier implementation of the CMS models. See, for example, page 50 of OECD (2004).

ANALYSIS OF THE FUNCTIONING OF THE CHEMICAL LEASING BUSINESS MODEL

5.1 Introduction

There is evidence that the servitisation of manufacturing companies has led to an improvement of the business performance of manufacturing companies facing severe competition and erosion of product margins. CMS and ChL also have some associated costs due to different factors, such as the unclear responsibility in the case of an accident, the loss of control over processes by the users, the high dependence on the suppliers, the potential uncertainty of environmental improvements, and the issues of trust and access. To analyse the functioning of the ChL contract, some of the concepts of contract theory are used, so as to describe the dynamics with the presence of hidden information, hidden action, adverse selection and moral hazard. These are put into the context of the increased servitisation of chemical manufacturing companies.

The differences between products and services have been explored by the services marketing literature since the 1960s. Although there have been debates on the feasibility of the characteristics identified to differentiate products and services, there is a wide consensus that the four main ones are:

- Intangibility: Darby and Karni's (1973) seminal paper on credence goods¹² highlight the fact that the degree of tangibility has implications on the ease of evaluating the quality of the purchased good. If an item is tangible, it is easy to evaluate prior to purchase;
- Inseparability¹³: services are delivered and consumed simultaneously and therefore the quality of services also depends on customers, since service delivery is a social interaction process where both sellers and buyers are involved;
- Heterogeneity: there is the potential for high variability in service delivery;
- Perishability: services cannot be stored and carried forward to a future time period.

Credence goods markets are characterised by information asymmetries that can be summarised by the following sentences:

- *Consumers do not know what they need, but they observe the utility from what they get;*
- *Consumers know what they want or need, but observe neither what they get nor the utility derived from what they get (Dulleck et al, 2011).*

Some of the factors that affect behaviour in services markets that have been explored by researchers are:

¹² Goods whose impact on consumers' utility is not completely revealed even after consumption.

¹³ Referred also as "simultaneity".

- Liability: the service supplier's obligation to provide a service of sufficient quality to meet customers' needs;
- Verifiability: the service supplier's obligation to charge for the quality provided;
- Reputation: the possibility for the customers to identify their trading partners;
- Competition: the opportunity for the customers to choose from several suppliers.

Traditionally, economies of scope have been considered an important incentive for entering markets related to the core business. However, companies may also benefit from diversification through information asymmetry, especially when they diversify into service business. Due to the existence of information asymmetry between users and suppliers and in order to minimise information acquisition costs, users are likely to choose suppliers from whom they are already buying products. Consequently, information asymmetry may provide suppliers with incentives to diversify into service business, so that they can exploit their customer relationship and reputation on existing products.

The information acquisition costs are determined by three types of attributes:

- Search qualities: attributes that prospective users can evaluate prior to purchase;
- Experience qualities: attributes that users can determine during or after consumption; and
- Credence qualities: attributes that users may not be able to evaluate even after the consumption (Darby and Karni 1973), e.g. because of the customer's lack of technical expertise.

The higher are the credence qualities, the higher the information acquisition costs are. The CMS and ChL market is characterised by information asymmetry and high information acquisition costs that may lead to adverse selection and moral hazard.

In order to understand when a ChL contract may be the optimal choice in terms of governance structure, it is important to introduce some of the notions on which contract theory is based. Contract theory looks at how different parties (individuals and businesses) make legal agreements in order to deal with uncertain situations and in particular in the presence of information asymmetry. Together with information economics, incentive theory and organisation theory, it forms the core of industrial economics and it is an active research area in economics, finance, management and corporate law. The study of the process by which scarce resources are allocated to their most efficient uses (the object of economics) has evolved significantly starting from the 1940s. Until the conceptual breakthrough realised through the work of Arrow and Debreu (introduction of the idea of "state-contingent" commodities) and by von Neumann and Morgenstern (formulation of the theory of "choice under uncertainty"), formal analysis could be performed only on simple situations of exchange of goods and services. In the 1960s and 1970s, the concepts of "private information" and "hidden actions" in contractual settings, and the related notions of "adverse selection" and "moral hazard"¹⁴ allowed the development of the first formal tools for the theory of economic institutions. Finally, in the 1980s and 1990s, the notions of "contract renegotiation",

¹⁴ Moral hazard and adverse selection are two possible consequences of asymmetric information or ineffective information pricing. Adverse selection occurs when one party of a deal has more accurate and different information than the other party. This changes the selected level of market transactions. Moral hazard occurs when a party provides misleading information and changes his behaviour when he does not have to face consequences of the risk he takes. This changes the slope of market transactions.

“relational contracts” and “incomplete contracts” allowed the analysis of ownership and control rights and, ultimately, of long-term and dynamic contracting (Bolton and Dewatripont, 2005).

A contract is a mechanism employed by two or more economic actors to coordinate their behaviour and bind themselves to a desired path of action. In an ideal world, there would be symmetric information between all actors involved in the contract and the courts. This would allow for a complete contingent contract to be written that governs the actors’ actions in every possible state of the world leading to an efficient allocation of resources (Pareto efficiency). Actors would not have an incentive to deviate from these actions because information could be communicated and verified to the courts without cost. Thus, any deviation from the agreed action would be punished according to what is established in the contract (Schmidt, 1994).

In real world transactions however, actors are characterised by bounded rationality and opportunism. There are a large number of possible contingencies or states of the world that could exist and this makes it nearly impossible to specify all responses to different states of the world that may occur. The impossibility to foresee all contingencies leads to the making of contracts that are inherently incomplete. When a contingency that has not been regulated through contractual arrangements leads to information asymmetry, the actors may try to leverage their position by strategically using the information held (opportunistic behaviour). The attempt to limit opportunistic behaviour leads to transaction costs (e.g. cost of writing and enforcing contracts, cost of renegotiation) that cause the outcome of private bargaining between actors not to be Pareto efficient. In summary, bounded rationality and opportunism imply transaction costs that determine the choice of the governance structure.

Governance structure choices exist between two opposite ends: the market and the firm. The possibilities in between are considered hybrid governance forms. From the transaction cost economics perspective, the market is the least costly governance structure due to its lack of administration costs and it is assumed that it would be the automatic choice of governing transactions in the absence of transaction hazards. From the opposite perspective, the firm transactions are governed by a hierarchy structure that implies administration costs (Williamson, 1985).

Table 5-1 summarises the differences between market and firms according to four key attributes of alternative governance structures: incentive intensity, administrative control, adaptation and dispute resolution.

Table 5-1: Key attributes of alternative governance structures		
	Market	Firm
Incentive intensity (the extent to which compensation drives productivity)	High powered incentives (reward output)	Low powered incentives (reward input)
Administrative control (the degree to which actors can effectively coordinate management decisions)	Autonomous control	Administrative control
Adaptation (the level of speed and efficiency of the decision-making in different situations)	Autonomous adaptation	Co-ordinated adaptation
Dispute resolution	Legal recourse to resolve disputes	Senior manager resolves disputes
<i>Source: adapted from Toffel (2002)</i>		

In this context, transaction hazards can arise from three key transaction characteristics:

- Asset specificity;
- Uncertainty; and
- Frequency.

These determine the choice of the optimal governance structure.

According to Williamson (1983)¹⁵, there are four different types of asset specificity: site specificity, physical assets, human assets and dedicated assets. The transactions regulated through ChL contracts are characterised by high asset specificity: the activities of ChL are carried out at the user production sites (site specificity), regard specialty chemicals (physical assets) and require specialised training (human assets) and production processes and procedures that are customised to the user's needs (dedicated assets). High asset specificity transactions are less likely to operate efficiently within a market governance structure and, indeed, ChL is one of the governance structures among the spectrum of the hybrid forms that is closer to the firm governance structure (hierarchy). This is due to the substantial risk that the supplier that invested in specific assets could be blackmailed by its counter party as those assets may not be redeployable (Toffel, 2002). Uncertainty (the impossibility to foresee all contingencies) and the frequency of transactions (more frequent transactions provide more occasions for opportunistic behaviour) exacerbate this risk. By providing more administrative control and co-ordinated adaptability, hierarchical governance regulates more efficiently frequent transactions involving higher degrees of uncertainty.

Servicizing contracts can mitigate information asymmetries and transaction costs through the realignment of incentives in the supplier-user relationship. However, these contracts can also lead to new types of transactional hazards, such as bilateral dependence and monopoly. Toffel (2002) analyses these risks and suggests possible mitigation strategies.

5.2 Comparative Analysis of ChL with Traditional Contracts

5.2.1 Information asymmetries, adverse selection and moral hazard in traditional contracts

Mitigation of ex-ante informational asymmetries and ex-post costs regarding chemical quality

Within a typical transaction, the supplier of a chemical will tend to have more information on the product's key characteristics (e.g. efficacy, purity, lifespan, compatibility, recyclability etc.) than the user. This informational asymmetry persists as the supplier is primarily interested in profit maximisation and has little incentive to provide information to the user that could result in them selecting a competing product. The supplier's concerns regarding product quality are limited to the extent to which the product's attributes could result in reputational damage and weaken its competitive position. Moreover, due to opportunism, the supplier has an incentive to make exaggerated claims about the product's characteristics through its marketing activities. As several characteristics may be largely unobservable ex-ante (i.e. hidden information), the user faces a problem of *adverse selection* prior to entering contracts under the traditional supplier-user relationship. The screening of potential suppliers therefore leads to greater transaction and search costs for the user. For instance, a user may conduct preliminary testing of a chemical substance to ensure its compatibility and quality. Furthermore, the user may incur costs ex-post due to poor product selection, which, for example, results in inefficiencies and waste.

Under a ChL contract, the informational asymmetries between the supplier and user become less pertinent. As the user only pays for the chemical's functionality and the supplier incurs the costs associated

¹⁵ Cited in Toffel (2002).

with a poor quality product (e.g. short lifespans and increased waste disposal), the supplier has an incentive to improve the inherent characteristics of their chemical and ensure processes are optimised within the user's plant. Differences in quality between suppliers would be reflected in each of their respective service prices. Contractual arrangements under ChL therefore allow users to mitigate the ex-post contractual hazards associated with typical sales transactions (e.g. increased costs due to poor quality product selection).

By changing the payment mechanism, ChL transforms incentive intensity and provides stronger incentives for the supplier to reduce the cost of the product's functionality and therefore to research innovative and cost-saving methods to improve its profitability vs lowered power incentives of the user to manage the chemical input that is not the core of its activity.

The less critical the chemical input (or asset) is to the user's profitability, the more likely the user is to seek CMS or adopt ChL. Moreover, the higher is the specificity of the assets, the greater is the opportunity by the supplier to exploit its better knowledge in managing the chemical to enhance profitability for both parties (Toffel, 2002).

Incentive alignment and mitigation of ex-ante informational asymmetries regarding optimal chemical use

Along with the chemical's key features, the supplier also has private information regarding the chemical's optimal use. Under the traditional supplier-user relationship, the chemical supplier has no incentive to provide this information to the user because its profitability is tied to the quantity of chemicals sold; it therefore benefits from user mismanagement of the chemical. Toffel (2002) provides the example of a paint manufacturer, which profits when its customer uses the paint inefficiently and has to buy more. Consequently, the supplier benefits from the ongoing information asymmetry with the user.

In contrast, ChL contracts compensate the supplier of the chemical on the basis of the functionality or the service the chemical provides. As the supplier retains ownership of the chemical, it has an incentive to reduce the user's consumption of chemicals and improve the efficiency of its production processes – an objective which is also shared by the user. The decoupling of the economic value added from the consumption of chemicals is what generates environmental benefits, together with the supplier's incentive to extend the chemical product life span or improve its recyclability or ease of management.

5.2.2 Information asymmetries, adverse selection and moral hazard in ChL contracts

Ex-ante informational asymmetries and ex-post costs regarding service quality and service volume

While the ChL model reduces the user's uncertainties regarding product quality that are present within traditional relationships, new concerns may arise over the quality of the service provided by the potential suppliers. ChL makes the user more dependent on the supplier. The user has to rely on the supplier not to abuse this dependency after the contract has been signed, for example, by leveraging its position to renegotiate more favourable terms with the threat of hold-up. As the supplier's type and intended actions are largely unobservable ex-ante, the user may face both a problem of adverse selection and moral hazard (i.e. where the supplier acts in a way that is detrimental to the user after the contract is signed). Nevertheless, this problem could be mitigated to some extent through contractual safeguards, especially if the user is able to stipulate a minimum level of service, which is easier to measure when compared with traditional supplier user relationships.

ChL contracts may pose problems of adverse selection for the supplier too. While suppliers have an informational advantage with regards to the quality of their service and product, users also know more about their projected service requirements in terms of quantity and quality. Under a ChL arrangement, the supplier makes a considerable investment in the downstream production processes of the user (e.g. human

and physical capital) and its profitability therefore depends on the volume of service required by user, for which it charges a service fee. During the initial bargaining process, it may be in the user's interest to leverage its position by disclosing strategic estimates of its service requirements. For instance, if a high projection lowers the service fee offered by the supplier, the user will have an incentive to disclose optimistic forecasts. As the supplier cannot observe the user's actual service requirements ex-ante, it faces a problem of adverse selection.

Increased bilateral dependency

As the relationship between supplier and user changes to a long term service contract, ChL inherently leads to greater integration and dependency between the two parties. Firstly, if the chemical supplier becomes responsible for a key process within the user's operations, there is the risk to the user of potential hold-ups (either accidental or strategic) due to the supplier's inability to provide the agreed service.

As an illustrative example, Toffel (2002) presents the case of a CMS supplier that manages the paint workshops for its downstream user (in terms of the logistics, application, waste management etc.). The entire production process could be disrupted if the supplier decides to leverage its position and renegotiate the terms of the agreements by threatening to hold up the user. On the other hand, suppliers could also be negatively impacted through a ChL agreement. The nature of the ChL business model means that suppliers must invest a significant amount of time and capital (both human and physical) from the outset of the agreement to ensure that the chemical is used in the most efficient manner, all of which represents an opportunity cost. To recover these costs, the supplier typically charges a service fee and/or shares in the cost savings generated by the model. However, if the user decides to decrease the volume of service provided by the supplier, the supplier's profitability could suffer.

Potential for bilateral monopoly

Contractual arrangements for assets with high levels of specificity (i.e. the degree which human or physical assets are locked into a trading relationship) can lead to existence of bilateral monopolies (Dietrich, 1994). A ChL contract requires the supplier of a chemical to make non-redeployable investments in the provision of a highly specialised service to the user. In the case of ChL, the supplier might gain a comparative advantage over its competitors through its close interaction with the user. Compared with traditional supplier-user relationships, ChL arrangements require far greater levels of co-ordination and knowledge transfer between the actors. Consequently, the supplier may gain more detailed knowledge of the users operational requirements, which allows it to offer a more tailored and competitive service vis-à-vis other suppliers. While the initial process of bidding for a ChL contract may be competitive, the information acquired by the successful service provider may provide it with such a significant advantage that a small numbers problem persists in following contract renewal periods¹⁶.

Transferal of supplier/product selection risk

Under the traditional supplier-user relationship, the user incurs the costs of searching for the correct chemical for its intended purpose. The user must incur the costs of screening potential suppliers and products for their suitability. Furthermore, after the contract has been signed with the supplier, the user incurs any costs associated with inappropriate supplier or product choice. Under a ChL contract this risk is reversed. The supplier now incurs any initial search costs related to the selection of a chemical that meets the customer's service requirements and minimises its overall costs. As the supplier takes on responsibility

¹⁶ Williamson calls this reduction in the competitiveness of bidding on contracts characterised by asset specificity "fundamental transformation".

for waste management and recycling at the chemical's end-of-life stage (including liability elements), any incorrect product choice could be very costly.

5.2.3 Mitigation of ChL problems

Toffel (2002) discusses various contractual safeguards to mitigate the information asymmetries and the adverse selection and moral hazard situations that may occur in servicing contracts:

- To mitigate the risk of bilateral dependency, the user may seek the inclusion of penalties in the contract in the case of service unavailability or production downtime. To protect its investments, the supplier can instead require minimum service volumes.
- To mitigate the risk of the users claiming higher service volume needs to achieve discounts, suppliers may offer such discounts retroactively, upon achievement of certain volume targets.

It should be noted that, equally and probably more than for other contract types, ChL relies on a high level of trust between supplier and user. ChL contracts between parties that value their reputation can be expected to be more informal and stipulate fewer contingencies. Moreover, in order to gain a progressively higher level of trust, ChL may be adopted as the last stage of a relationship between supplier and user, starting from the purchase of mere chemical substances to the implementation of a total CMS, passing by the adoption of only some chemical management services at first.

CONCLUSIONS AND RECOMMENDATIONS

The literature analysing the implementation of the CMS and ChL models agrees that, by aligning the chemical provider's and chemical user's incentives through changing the compensation mechanism from volumes of chemicals sold to service delivered, both parties can achieve economic and environmental benefits from improved performance, chemical handling and waste management.

The models have been mostly implemented in the automotive, electronics, aerospace and metalworking sectors and studies estimating their penetration in the market are available for Austria, Germany, Sweden and the US. Examples of successful implementation of the models are available for developed, emerging and in transition economies, with the latter thanks to the work of UNIDO in promoting the ChL business model.

The legislative frameworks, in particular with regard to the environment and workers' health and safety, the increased international competition and the increase in the demand for greener consumer products play major roles in the uptake of the ChL model.

However, barriers to the diffusion of the model have been identified by several authors. These are: strict and differing national waste legislations, lack of customer demand, liability risks, lack of awareness of the life-cycle cost of chemicals, labour policies, limited set of skills of service suppliers, fear of losing know-how to the supplier and reluctance of the supplier to take on all the investments. Lay (2014) argues that it is the inherent nature of the CMS and ChL business models that make their wide adoption difficult, highlighting the long-term dependency between the contractual parties, requiring a high level of trust from both sides.

The analysis of the economic features of the ChL model using the concepts of Contract Theory confirms the importance (and the complexity) of contractual safeguards for mitigating information asymmetries, the increased bilateral dependency, the risk of bilateral monopoly and the transfer of supplier/product selection risk from the chemical user to the service supplier.

On the basis of the identified barriers and of the recommendations provided by different authors, the following initiatives could be undertaken within countries to facilitate the take-up of the ChL model:

- Research and support for diffusion of the model:
 - Conduct research on the diffusion of the CMS and ChL models in countries other than Austria, Germany, Sweden and the US: while the penetration rate of the models in these countries have been investigated, no market analyses for the other OECD countries have been found;
 - Support the development of pilot-projects, in particular in those countries where the diffusion of CMS and ChL models has not been investigated: this would enable the identification of potential national policy constraints and the further development of best practices;
 - Launch national surveys on the obstacles to the implementation of the ChL model: this would serve both objectives of researching the diffusion of the model and of awareness raising;

- Research the diffusion and applicability of ChL model in industrial districts (or clusters): this may allow stakeholders to overcome the size constraints to the diffusion of the models, where several SMEs competing or part of the same supply chain may take part in the models;
- Explore what are the most effective transformational frameworks to facilitate the uptake of ChL model by firms: Oliva and Kalleberg (2003) propose a progressive step-by-step approach to move from a product-based to a service-based model, from identifying some potential first services to offer to finally taking over customer activity to deliver the outcome; Martinez et al (2010) propose an adaptive strategy with increasing levels of service and interaction between supplier and user; Meyer et al (2011) propose focused modular networked organisation to manage resources, knowledge and qualified staff; other authors believe that incremental changes are insufficient and propose instead the establishment of a single enterprise, as autonomous as possible, with the primary objective of providing the required service (Barnett et al, 2013);
- Opportunities for promotion of the model:
 - Promote training and education of managers on Product-Service Systems;
 - Create a database of CMS and ChL providers by industry sector, functional unit (service) and substance: this would facilitate prospective users in finding the optimal business partner and would allow the identification of those sectors and services for which a risk of strong dependency or monopoly exists;
 - Engage with industry associations and chambers of commerce at local level to raise awareness of the economic and environmental benefits of ChL models: while national and international industry associations have become familiar with these business models through the participation to international conferences and workshops, engaging industry associations and chambers of commerce at local level would ensure a more capillary awareness raising;
 - Engage with environmental NGOs and workers' unions: highlighting the environmental and health and safety benefits achievable through the implementation of the ChL model with these stakeholders would ensure their contribution. Awareness raising is one of their core competences and this may work as a boost to the diffusion of the model;
- Support moving towards implementation of ChL:
 - Offer technical support to analyses of life-cycle cost of chemicals in individual companies: free or subsidised quotes may serve as triggers to considering the implementation of the ChL model;
 - Assist companies in drafting the contracts: the drafting of ChL contracts is an onerous task that can be facilitated by public negotiators, which may reinsure both parties and draw on previous experience and best practices;
- Policy or financial incentives:
 - Investigate the possibility of slowing depreciation rates: this would make ownership less beneficial from a financial perspective and may therefore favour leasing models;

- Encourage shifting taxation from labour to resource consumption: this is already part of the Roadmap to a Resource Efficient Europe for 2020 (EC, 2012);
- Reduce VAT rates for Chemical Leasing: the European Commission has suggested that this may be justified for environmental reasons (EC, 2012);
- Promote the inclusion of CMS and ChL models in green public procurement: governmental organisations (that use chemicals in e.g. universities, hospitals, water treatment facilities) may play an important part in the diffusion of these models.

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