THESIS FOR THE DEGREE OF LICENTIATE OF ENGINEERING

Chemical Risk Information in Product Chains

The cases of paint and textile

KRISTIN FRANSSON

Division of Environmental Systems Analysis, Department of Energy and Environment

CHALMERS UNIVERSITY OF TECHNOLOGY

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KRISTIN FRANSSON

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Division of Environmental Systems Analysis, Department of Energy and Environment
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone + 46 (0)31-772 1000
www.chalmers.se

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Abstract

Chemicals are present in or have been used for production of a large number of products available for private consumers. There are many benefits and useful applications of chemicals, but risks and negative side-effects shall not be overlooked. Risks related to chemicals can occur during all steps of production and use of a product, and generally products are manufactured during a number of steps, with many different actors involved in production, use and waste management. In order to handle risks connected to chemicals in all steps of the product chain, chemical risk information is central.

The aim of this thesis is to describe how chemical risk information is handled in product chains and which information that is communicated. A second purpose is to investigate how the handling of chemical risk information is affected by external factors, such as legislation. In order to do this, two examples of consumer products (textile and paint) affected by different legislation and with production processes taking place in different geographical context have been studied. The main method for data collection has been semi-structured interviews and content analysis has been used for analysis of the material.

The results show both differences and similarities between the two studied industries. The most profound difference between the two cases was the communication of chemical risk information in the product chains. For the textile case, most information was communicated up-stream between companies, from the retailers to the direct suppliers in the form of a list of restricted substances while for paint, chemical risk information was central in many parts of the product chain, particularly in the manufacturing steps and mainly communicated down-stream between companies. This difference is strongly associated to the considerably different legislation between the two industries. Another important conclusion is that the geographical context matters, both in terms of possible misunderstandings of information due to translation and culture and in terms of local traditions and degree of development in producing countries.

One similarity between the two studied industries is that communication with colleagues from other companies in the industry was considered important for interpretation of legislation and information exchange. An additional similarity between the cases was that the perceived interest from private consumers regarding chemicals in the products was low.

Keywords: Chemical risk information, REACH, supply chains, product chains, paint, textile

Appended papers

Paper I

Kristin Fransson and Sverker Molander

Handling Chemical Risk Information in International Textile Supply Chains

Submitted to Scientific Journal in 2011, under review.

Paper II

Kristin Fransson, Yuntao Zhang, Birgit Brunklaus and Sverker Molander

Managing chemical risk information: A case of Swedish retailers and Chinese suppliers in textile supply chains

Manuscript, accepted for publication in Sustainable Fashion and Textiles, edited collection, Greenleaf publishing.

Paper III

Kristin Fransson, Birgit Brunklaus and Sverker Molander

Chemical Risk Information in the Product Chain of Consumer Paint

Accepted for publication in Journal of Industrial Ecology in 2012.

Preface

This thesis was conducted within the research project Inflow - "Towards Improved Interactions in the Two-Way Flow of Risk-Related Chemical Information – The Cases of Clothing, Toys, and Paint" that started in 2007. The project had an aim to "describe and provide an analysis of the information flow in the socio-technical systems related to hazardous chemicals in consumer products" (Klintman, 2006). The project group was interdisciplinary, including researchers from different fields and universities, all participating and contributing with their knowledge and perspectives. My sub-project within the group has been to investigate how chemical risk information is handled in different steps of product chains for consumer products illustrated by the cases in this thesis. Other members of the group have dealt with interpretations and evaluations of the chemical risk-relevant information and demand-shaping processes in supply chains for consumer products. The project has resulted in a number of different publications (Sjöström, 2008, Klintman, 2009, Stenborg, 2010, Hollander, 2010, Sjöström, 2011, Stenborg and Klintman, 2011, Klintman and Stenborg, 2011, Hollander, 2011).

Acknowledgements

Here, I would like to express my gratitude to everyone who has given me help and support during the work with this thesis. First, I would like to thank my supervisor Sverker Molander for his gentle, supporting and wise guidance and his positive attitude. My colleagues in the Inflow project, Mikael Klintman, Ernst Hollander, Jesper Sjöström and Emelie Lundborg have all been sources of inspiration, giving me insights in new academic disciplines. Birgit Brunklaus came in late in the project, providing mee with valuable comments on my manuscripts. Thank you also Anne-Marie Tillman, my examiner, whose intelligent comments strengthened this thesis a lot. Thanks also to Anne-Marie for being a good leader of the division.

The financial support for this research was given by Formas - The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning, which is gratefully acknowledged as well as the companies, organizations and individuals who participated in the interviews.

Past and present colleagues at ESA, thank you for company at the lunch table, valuable discussions, and interesting seminars. In particular, I would like to thank Kathrine and Monica for all administrative support. Rickard: thanks for your wise and thoughtful comments on my work and for valuable discussions about research, life and everything in between.

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Slutligen vill jag tacka de två personer som varit viktigast för mig de senaste åren. Tack Michael och Folke för att ni stöttar mig när jag behöver det och för att ni ger mig kärlek, avkoppling och glädje!

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1 Introduction

Many of the products used in everyday life either contain synthetic chemicals or have been produced using process chemicals. There are many benefits and useful applications of chemicals and chemicals are obviously of crucial importance for everyday life of most people in the developed world. Today, there are a large number of available synthetic chemicals and the number is increasing dramatically. During the time period 1965-2007, the number of chemical substances (including sequences) in the CAS-registry system increased from 212 000 to 93 607 000 (Chemical Abstracts Service, 2008), which corresponds to an average increase of 16% every year, and the number of substances continues to increase (Chemical Abstracts Service, 2012). However, there are risks and negative side-effects of chemicals that should not be neglected. For instance, Colborn et al. (1996) writes about endocrine disruption due to chemicals, and the Swedish film “Submission” (Jarl, 2010) has contributed to giving problems connected to hazardous chemicals more attention, both on a Swedish and international level.

Today, there is a large data gap between the number of available chemicals and the number of chemicals we have information about. For instance, Allanou et al. (1999) concluded that the necessary information to carry out a simple risk assessment of a chemical is lacking for approximately 75% of the substances produced in high volumes. According to Applegate (2008), this figure is probably underestimated when taking all available chemicals into account since it only includes high production volume chemicals which are a small portion of all chemicals. In addition, it is probable that the greatest amount of data exist for high production volume chemicals. The large number of available chemicals in combination with the knowledge that chemicals may cause adverse effects and the lack of information for many chemicals implies that there is a need for more and better information about chemicals.

The concern about chemical risks has led to activities among both authorities and companies. For instance, one of the Swedish environmental objectives is to create a toxicant free environment (Krishnan, 2008) and the Swedish Government has given the Swedish Chemicals Agency the assignment to produce an action plan for a toxic-free everyday environment during the years 2011-2014 (Swedish Chemicals Agency, 2011a). Historically, regulations of chemicals began in a context of criminal law, with a focus on chemicals known to be toxic. During the last two centuries, legislation has been developed to control hazardous chemicals in pharmaceuticals, occupational safety, clean air and water and food quality (Bengtsson, 2010). In 2007, the EU legislation REACH – Regulation, Evaluation, Authorization and restriction of CHemicals (EU, 2006) came into force as a measure to increase the knowledge about chemicals and put up restrictions for hazardous substances on an EU level. The management of chemicals among a number of companies that actively work to decrease chemical risks associated to their products is described by Scruggs and Ortolano (2011) and Esty and Winston (2006) rank chemical hazards among the top ten environmental issues businesses will need to address in the coming years.

Recently, more and more attention has been given to chemicals in articles (Massey et al., 2008, Rudén and Hansson, 2010, ChEmiTecs, 2012). For instance, NGOs in the US have called for consumers' right to know more by demanding that data about chemical use in manufacturing and products should be made publicly available (Iles, 2007) and Massey et al. (2008) have pointed out the importance of chemical risk information in order to make it possible for consumers to make informed choices. The growing attention concerning chemicals in products and the fact that consumers in general do not have detailed knowledge about chemical risks make it important to study chemical risk information for consumer products.

Risks related to chemicals can occur during all steps of production and use of a product, and generally products are manufactured during a number of steps, with many different actors involved in production, use and waste management. Consequently, with increasing globalization, the chemical-related risks associated to a product are often spread over several countries and it has been pointed out that developing countries will have difficulties to keep up with industrial countries when it comes to the management of chemical risks due to economical reasons (Bengtsson, 2010). When discussing production processes involving several steps, the term supply chain is often used to describe the management of production processes (Lambert and Cooper, 2000, Coyle et al., 2003). In discussions also including use and waste management, the term product chain (Boons, 2002) is more suitable. According to Seuring (2008), studies based on more than one stage of a product chain are rare and there is a need for more case studies involving actors from several steps of a supply chain.

Two products available for private consumers and with considerably different product chains, both when it comes to the type of actors involved and the geographical context are paint and textiles. These products have been associated to risks to human health, both historically (Hollander, 1995, Jenkins, 1978) and recently (Choi et al., 2010, Trudel et al., 2011). The environmental impacts of a product during all steps of production, use and waste management can be assessed in terms of a Life Cycle Assessment (LCA) (Baumann and Tillman, 2004, ISO 14040, 2006) and such have been done both for paint (Axelsson et al., 1999, Papasavva et al., 2001, Stromberg, 2004) and for textiles (Dahllöf, 2004, Wendin, 2007, Steinberger et al., 2009, Chapman, 2010). However, in these LCAs little attention is given to environmental problems related to chemicals. Risks to human health and the environment due to chemicals in different types of paint have instead been investigated in a number of studies (Hall Jr et al., 1999, Jacobson and Willingham, 2000, Armstrong et al., 2000, Thomas et al., 2003, Konstantinou and Albanis, 2004, Choi et al., 2010) and the use of chemicals have been pointed out as a large environmental problem related to the production of textiles (The Swedish National Chemicals Inspectorate, 1997). The Swedish research institute Swerea IVF (Olsson et al., 2009) has studied the use of chemicals in clothes and Boström et al. have written about responsible procurement in relation to chemical risks in textiles (2011).

Considering environmental information in general, Svending (2003) has discussed the need for harmonized systems for environmental information within a whole industry in order to increase credibility and comparability. Erlandsson (2007) writes about how environmental information is communicated to end consumers, and also discusses how media and NGOs affect a company's information management and Leire has studied the role of information tools, such as ecolabels, Safety Data Sheets and environmental policies in green purchasing (2009). More specifically regarding chemicals, Massey et al. (2008) have investigated the need for chemical information about products and Kogg and Thidell (2010) have studied systems for providing information regarding chemicals in products. Kogg has also studied how requirements regarding chemicals are communicated up-stream in textile supply chains (2009).

Above, a number of issues which serve as motivation for this work are outlined:

- The dramatically increase in chemical substances and their potential adverse effects.
- The considerable lack of information about risks related to chemicals.

- The establishment of new regulations in order to increase knowledge and information about chemicals.
- The particular lack of risk-related information on chemicals in articles.
- The importance of considering chemical risk information from a chain perspective.
- The little attention given to chemical impacts along the product chains of paint and textiles.

The increasing number of chemicals and the scarce information implies that, in order to avoid unacceptable chemical risks in the future, there is a need for more information and knowledge about chemicals and chemical risks along product chains. This is therefore the focus of this thesis.

1.1 Aim of the thesis

The aim of this thesis is to describe how chemical risk information is handled in product chains and which information that is communicated. A second purpose is to investigate how this handling of chemical risk information is affected by external factors, such as legislation. In order to do this, two examples of consumer products (textile and paint) affected by considerably different legislation and with production processes taking place in different geographical context have been studied and differences and similarities between the two products have been investigated.

1.2 Guide for readers

First, a brief background will be given before the case studies reported in Papers I, II and III are described. Then, there will be a discussion where differences and similarities between the results for the studied products are analyzed and finally some conclusions are drawn. The background begins with a chapter in which the different chain perspectives used in Paper I, II and III are explained. Then there is a chapter on information and chemical risk. Here, different types of chemical risk information are described, including information on chemical regulations and labelling.

2 Background

2.1 Supply chains and product chains

Processes related to a product normally take place in several steps, such as raw material acquisition, production, retailing, use and waste management. These processes include material and physical actions as well as social actions, such as exchange of information and trade relations. To understand and handle these complex systems, researchers in different fields have developed concepts and frameworks. Examples of such concepts are Supply Chain Management (Lambert and Cooper, 2000, Coyle et al., 2003, Nagurney, 2006, Seuring and Müller, 2008), Life Cycle Assessment (Baumann and Tillman, 2004, Rebitzer et al., 2004, ISO 14040, 2006, Guinée et al., 2011), Product Chain Management (Boons, 2002), Commodity Chain Analysis (Gereffi, 1994, Raikes et al., 2000, Ponte, 2002, Bair, 2005) and Value Chains (Evans and Wurster, 1997, Stabell and Fjeldstad, 1998, Ernst and Kim, 2002, Gereffi et al., 2005). The main difference between the different concepts is the context in which they are used and the boundaries regarding which parts and aspects of the chain to include. In Paper I and II, the handling of risk information is related to the concept Sustainable Supply Chain Management (SSCM) and in Paper III the product chain concept is used.

A supply chain can be described as a system or a network of organizations, people, technology, activities and resources involved in moving a product or a service from supplier to customer (Nagurney, 2006). Thus, it normally does not consider activities such as use and waste management. When describing a supply chain, one important concept is the so called "focal company". The focal company can be any company depending on method choices and system boundaries chosen when studying a supply chain. In many studies, the focal company is the actor selling the product or service of interest on the consumer market (Coyle et al., 2003, Seuring, 2004, Gold et al., 2010). Starting from the focal company, the supply chain then includes all companies and organizations that the focal company interacts with, directly or indirectly (Lambert and Cooper, 2000). Consequently, supply chains are usually complex networks of suppliers and sub-suppliers. It has also been suggested that the complexity of supply chains has increased as a result of global trade (MacCarthy and Atthirawong, 2003, Teuscher et al., 2005, Meixell and Gargeya, 2005). A schematic representation of the structure of a supply chain is given in Figure 1.

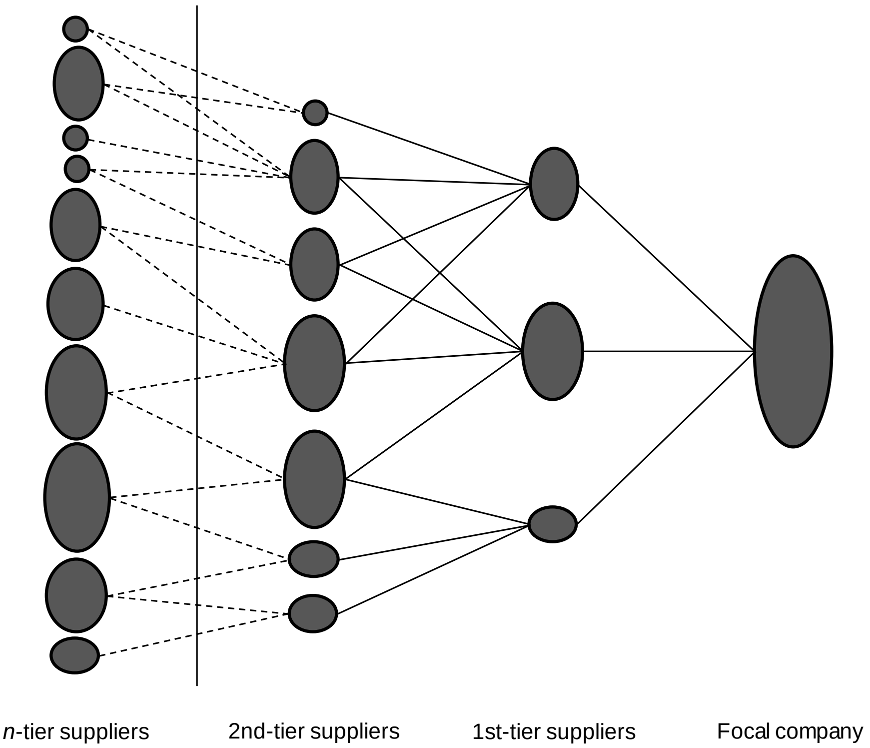

Figure 1 An illustration of the complexity of a supply chain, inspired by Kogg (2009), where each of the blobs symbolize a company participating in the supply chain. In reality, a supply chain is usually even more complex and extensive.

Sustainable supply chain management (SSCM) is a concept which broadens supply chain management to include economic, ecological and social aspects of the products, as well as information and capital flows (Svensson, 2007, Carter and Rogers, 2008, Seuring and Müller, 2008, Gold et al., 2010). Seuring and Müller (2008) have reviewed SSCM literature and consider the main driver for SSCM activities within a company to be external pressure from different groups, such as authorities, customers and other stakeholders.

The concept of product chains is broader than that of supply chains since it also includes retail, use and waste management. Research on product chains originates from studies on global value chains and global commodity chain analysis (Gereffi, 1994, Dicken, 1994, Gereffi et al., 2005, Bair, 2005). In these studies, commodity chains are often described as networks of labour and production processes resulting in a finished commodity or as a linked sequence of functions in which each stage adds value to the process of production. However, Dicken (1994) writes that most attention is often given to the production steps, despite that important functions also take place in other parts of the chain, such as use and waste management. In addition, Hollander (2011) writes about the weaknesses in concepts such as supply chains and production chains, which most often only incorporates the production steps associated to a product, ending at focal companies or at customers buying the product. It can therefore be argued that commodity chain analysis and supply chain management is merely concerning the organization of global industries. The product chain concept has been further developed by several authors (Boons, 2002, Forman and Jørgensen, 2004, Vermeulen and Ras, 2006, Ras et al., 2007, Boons and Mendoza, 2010) and is often used in connection with the greening of product chains. According to Boons and Mendoza (2010), a product chain can be seen as a socio-economic system that parallels the energy and material flows associated to a product. These material and energy flows come from all parts of a product chain, including extraction of raw materials, production, use, disposal and transports.

The definition of product chains used in Paper III is: *"A product chain can be seen as a network of actors, including actors involved in the production process as well as retailers, consumers and waste management actors. The material flows in the product chain are results of interactions between actors"*.

Vermeulen and Ras (2006) include actors outside the product chain, such as government agencies, NGOs and research institutes in their framework. These external actors have different roles. For instance, governments can set up regulations, NGOs can analyse a company's actions critically and researchers can come up with new production methods, affecting the performance of the production process. Communication with external actors is a prerequisite for transparency and for increasing a company's knowledge about different actions taking place in the product chain.

2.2 Information and chemical risk

In order to be able to handle risks related to chemicals, information, knowledge creation and communication are crucial elements (Commission of the European Communities, 2001). In a product chain, information about risks need to be communicated both up- and down-stream. The communication directed down-stream, from suppliers to users need to include relevant information for the user to handle the product in a correct way and to minimize risks related to the product. This communication is often done through Safety Data Sheets (SDSs), hazard pictograms and ecolabelling. Risk-related communication directed up-stream in the product chain is a way for users to set up requirements for or ask questions about the chemical content of the product. It is also possible for down-stream users to request chemical risk information to be provided in a specific way. Other examples of chemical risk information directed up-stream in the product chain are questions from consumers regarding chemicals or requests from down-stream companies in connection with procurements.

In the following sections, the concept of risk will be described, followed by a section on information management. Subsequently, there is a section on regulatory measures in order to explain how chemical risks and chemical risk information are governed. The chapter ends with a section on voluntary labelling, a common way of communicating environmental performance to private consumers.

2.2.1 Chemical risks

In engineering contexts, risk is often defined as the probability of an adverse consequence (Bedford and Cooke, 2001). However, in environmental and health context, risk is generally defined as the probability of an adverse effect on man or the environment occurring as a result of a given exposure to a chemical mixture (van Leeuwen and Vermeire, 2007). Examples of risks related to chemicals are acute risks, such as fires, explosions and skin corrosion and long-term risks, such as reproductive toxicity and carcinogenicity (van Leeuwen and Vermeire, 2007). To assess environmental risks, environmental risk assessment (ERA) is a common method, often used for risk assessment of hazardous chemical substances (US EPA, 1998, van Leeuwen and Vermeire, 2007). An ERA follows a standardized procedure beginning with hazard identification, followed by exposure and effect assessment and risk characterization. When assessing risks related to chemicals, hazard identification involves gathering and evaluation of data regarding health effects or environmental effects of a chemical substance and under which conditions these effects are likely to occur. In exposure assessment, it is evaluated how large doses of the chemical substance humans or environmental compartments may be exposed to. This is done through measurements or modelling of the environmental fate of the substance. The outcome of an exposure assessment is often referred to as the “predicted environmental concentration” (PEC). Effect assessment is the estimation of the relationship between the dose of exposure and the severity of adverse effect. Often, a highest dose of the substance when no adverse effects are observed on a certain receptor is determined, the so called “predicted no effect concentration” (PNEC). In risk characterization, the likelihood of a risk is estimated through comparison of exposure in terms of PEC and effect in terms of PNEC. The general idea is that there is an indication of risk if the PEC/PNEC ratio is higher than one.

According to a social science view, risks can be perceived in different ways depending on who you ask. For instance, Slovic (1987) writes that many citizens rely on intuitive risk judgements. Reporting of hazards and accidents in media often influence the risk perception of these people. According to Burgman (2005), people are more likely to accept a risk when there is a high level of personal control and if an activity is voluntary. Contrary, people are less likely to accept a risk if the consequences are uncertain or if the risk has visible adverse consequences. Some examples of risk situations where people often underestimate or accept the risks are car driving and smoking while risks related to nuclear power and vaccination often are over-estimated. If the same thinking is applied on chemical risks, it can be suggested that risks for acute toxicity is perceived as larger compared to long-term risks, such as endocrine disruption.

2.2.2 Information management in and between chains

According to Checkland and Hollowell (1998), information can be viewed as data to which meaning has been attributed in a particular context (see Figure 2). They also discuss how a person's perception of information is affected by factors such as memory, knowledge and values and how information is viewed through each individual's cognitive filter. Thus, the same information can be perceived differently by two individuals.

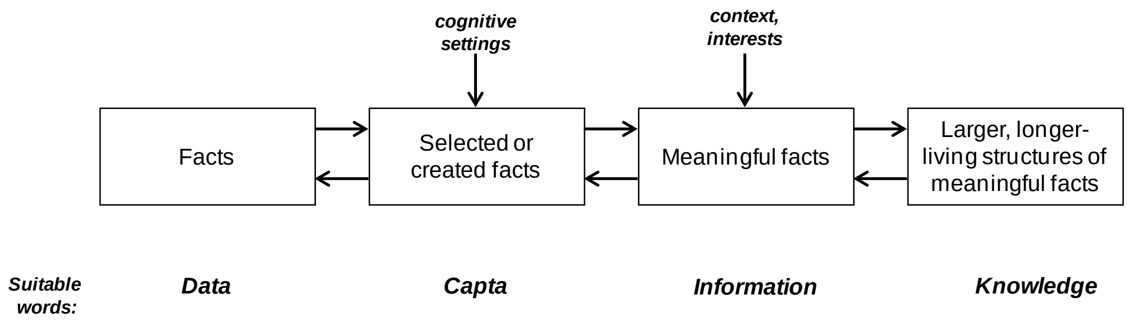

Figure 2 The links between data, capta, information and knowledge according to Checkland and Hollowell (1998).

Information is communicated both within and between organizations. Paper I and II deals with information transferred between organizations while Paper III also includes information communicated within organizations. One description of information processing in organizations is given by Choo (1996), who writes about four steps of knowledge making (Figure 3). The information gathered from the external environment or given by external actors is interpreted during the sense making process, during which it is chosen which information is significant. Then knowledge is created through conversion of the information to understandable units and processing of the information to make it more understandable. Subsequently, the organization has tools to make informed decisions. The view of Choo is extended by Checkland and Hollowell (1998), who also adds cognitive filters of groups and individuals in the organization and how created meaning from information can lead to purposeful action resulting in a new perceived reality.

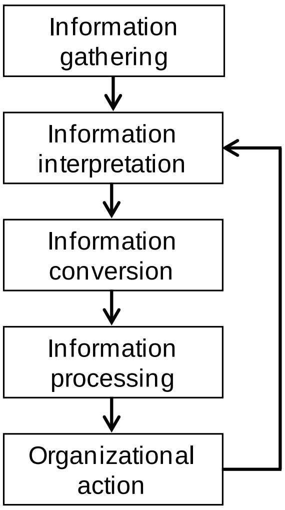

Figure 3. A description of information processing in organizations. The picture is adapted from Choo (1996).

Information between organizations can have several purposes and be communicated in several ways. Examples of organizations communicating with each other are companies, authorities, NGOs and industry organizations.

In supply chains, information transfer between companies is needed in order to link the different steps in the chain to each other and allow economic activities to be carried out. Traditionally, information has been viewed as moving up-stream in the supply chain, from the focal company to its suppliers and further to the sub-suppliers. This information is typically demand and sales data with the objective to bring goods to the customer (Lambert and Cooper, 2000, Seuring, 2004, Forman and Jørgensen, 2004). However, in reality, there are many other information flows which are directed both up- and down-stream in the product chain (Figure 4).

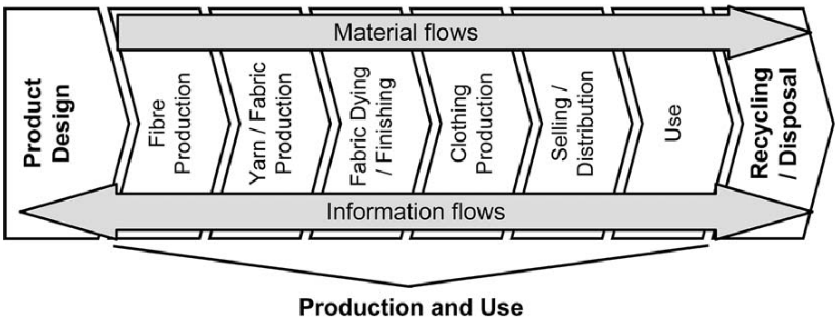

Figure 4. An example of a product chain for textiles, in which both information and material flows are included (Seuring, 2004).

Some examples of information directed down-stream are prices, delivery dates, inventory availability and order status (Lambert and Cooper, 2000). Other types of supply chain information seldom mentioned in scientific literature is, for instance, information about the products' quality, appearance and function, risks related to the product as well as social and ecological effects of the production processes. Communication in the supply chain can be carried out in several ways, such as through letters, brochures, articles, personal communication and the Internet. Specific requirements, for instance regarding the use of chemicals in production, generally becomes part of a focal company's purchasing specifications and are enforced through the procurement process (Lippmann, 1999).

Communication of environmental information in supply chains has been discussed by Solér et al. (2010). They write that information can be distorted when it is transferred up- and down-stream in supply chains and in order for supply chain members to perceive information as useful it has to be accurate, timely and properly formatted. Correspondingly, Legner and Schemm (2008) writes that poor data quality, especially outdated or wrong product information is a problem for the communication between retailers and suppliers. They also highlight the importance for retailers and suppliers to interpret data in the same way. It has been suggested that large geographical distance between senders and receivers of information can result in mismatches considering what is perceived as meaningful information (Solér et al., 2010). This can be of large importance for companies with multi-national supply chains.

2.2.3 Regulatory background

Chemicals are regulated in a number of different ways, both nationally and internationally through laws, agreements and conventions. The intention of regulations is often to decrease risks to human health and the environment. Here, authorities can set up regulations and restrictions but it is also important to follow up how such regulations are met by actors handling chemicals within companies. Some examples of international initiatives are Strategic Approach to International Chemicals Management (SAICM) (2012) and Globally Harmonised System of Classification and Labelling of Chemicals (GHS) (United Nations, 2009). SAICM is a voluntary policy framework under the United Nations with an overall objective to achieve a sound management of chemicals in order to minimize significant adverse impacts on human health and the environment. The Globally Harmonized System of Classification and Labelling of Chemicals (GHS), is a global initiative, governed by the United Nations (United Nations, 2009). GHS proposes globally harmonised hazard communication elements, including labels and safety data sheets. This system aims at facilitating international trade while protecting human health and environment (United Nations Institute for Training and Research, 2008, United Nations, 2009).

In addition to the international agreements, there are national and regional regulations. Two of the most influential are the Toxic Substances Control Act (TSCA) (US Environmental Protection Agency, 2002) and the European chemical legislation REACH (Registration, Evaluation, Authorization and restriction of CHemicals) (European Commission, 2006). TSCA aims at protecting the public from unreasonable risk of injury to health and environment by regulating manufacture and sale of chemicals. For REACH that came into force in June 2007 and will be implemented in several steps until 2018, the overarching goal is the safe use of chemicals. One aim of REACH is to fill the lack of information regarding chemical risks since this has been pointed out as a major obstacle for an efficient chemicals management (Commission of the European Communities, 2001).

Substances that are used or manufactured within EU are required to be registered, depending on the total mass of the substance for each manufacturer or importer and also depending on how hazardous the substance is. For the registration, data on identified uses, classification and labelling, guidance on safe use, data on chemical properties, hazard and environmental effects for the substance has to be collected. The data is, for instance, generated through chemical laboratory tests, animal tests and through comparison of substances to other substances with similar structure and known properties (so called Structure Activity Relationship). To avoid redundant testing, especially on animals, companies are obliged to cooperate in so called Substance Information Exchange Forums (SIEFs) when registering a substance and the information generated within the SIEF is registered at the European Chemicals Agency

(ECHA). In the future, hazardous substances will not only require registration, but also authorization from ECHA. Substances that will require authorization is being put on a list, the so called “candidate list for authorization”. This list is updated at regular intervals by ECHA and includes so called “substances of very high concern” that are carcinogenic, mutagenic, toxic for reproduction, persistent, bioaccumulative, toxic, very persistent or very bioaccumulative.

For substances and preparations which meet the criteria for classification as dangerous or those that are persistent, bioaccumulative and toxic (PBT) or very persistent and very bioaccumulative (vPvB), a Safety Data Sheet (SDS) has to be made. SDSs do not need to be supplied where dangerous substances or preparations are sold to the general public if enough information on dangerous properties and protective measures already is present on, for instance, the containers. However, SDSs have to be available on request. The appearance of SDSs is standardized in REACH and consists of information under 16 headings, such as hazards identification, first-aid measures and measures for personal protection, but also other types of information such as toxicological and ecological information shall be included in the SDS.

The appearance of the SDSs is also affected by the regulation on Classification, Labelling and Packaging of chemicals (CLP) (European Commission, 2008c). CLP is based on GHS and entered into force in January 2009 and aims at ensuring that hazards presented for chemicals are clearly communicated to workers and consumers in the European Union through classification and labelling of chemicals. Another chemical risk-related issue affected by CLP are the hazard pictograms (Figure 5), which shall be available on the containers if a product is classified as hazardous (European Chemicals Agency, 2011). The intention with the hazard pictograms is to make it possible for workers and consumers to know about potential hazardous effects before they handle the product. The appearances of the hazard pictograms are currently undergoing changes in order to make them globally harmonised and this process will continue until 2015.

Figure 5 Examples of hazard pictograms according to GHS (United Nations, 2009, United Nations Economic Commission for Europe, 2012)

In order to assess risks for substances that are produced or imported in volumes over 10 tons per year, a Chemical Safety Assessment (CSA) should be made. In the CSA, risks arising from the manufacture and use of a substance are assessed to ensure that they are adequately controlled. A CSA is required to address the manufacture and all identified uses of a substance during all steps of its product chain. In the CSA, potential adverse effects of a specific substance shall be compared to the reasonably foreseeable exposure of the substance to humans and the environment. One important element of the CSA is the exposure scenario, which shall be attached to the SDS. In the exposure scenario, the manufacturing of a substance and the use of it during all steps of its product chain shall be described. In addition, measures undertaken by the manufacturer or recommended to down-stream users in order to control exposure of humans and the environment shall be included.

In REACH, there is a distinction between “substances”, “preparations” and “articles”. A short definition of substances would be that they are chemical elements and their compounds in its natural state while a preparation is a mixture or solution of two or more substances. An article is defined as an object which during production is given a special shape, surface or design which determines its function to a greater degree than its chemical composition (European Commission, 2006). For articles, the legislation is different than for substances. A producer or importer of an article is obliged to register substances in the article under some specific conditions. One example of a condition when an article has to be registered is if substances contained by it are intended to be released from the article during normal and reasonable foreseeable conditions of use and if the total amount of a specific substance present in the article exceeds 1 ton per year per producer or importer.

Another such condition is if a substance in an article is included in the candidate list for authorization and the volume exceeds a certain limit value. However, intended release only relates to substances such as fragrances that have a function when released and not to substances that might be released by washing or wearing of, for instance, clothes. Therefore this legislation does not have a large impact on many of the companies importing articles to the EU. This problem have been observed by, for instance, the Swedish Chemicals Agency (2011c) which has worked out a suggestion to strengthen the requirements for articles under REACH.

One part of REACH, which affects private consumers, is that they, on request, have the right to achieve chemical risk information about articles containing substances included on the candidate list for authorization within 45 days. How this rule functions in practice has been investigated by the European Environmental Bureau (2010) in five European countries. The study showed that the overall answer rate was only 22%, indicating that more awareness of this rule and better control of its implementation are desirable.

2.2.4 Voluntary Labelling

One common way for companies to communicate chemical risk information to private consumers is through labelling of products. Ecolabels are classified into three groups, type I, type II and type III according to the ISO standard (ISO, 2009). Type I is what is known as ecolabels, type II are self declared environmental claims and type III are environmental product declarations in which quantified environmental information is presented.

For type I ecolabels, certification criteria first has to be established for a product. These criteria are supposed to take into account environmental impacts from the product's entire life-cycle and are established by a labelling organization after consultation with several different stakeholder groups. When the criteria are established, companies can be certified to use the ecolabel on products or services that fulfil the criteria , 2004). For the product groups studied in this thesis, some of the most commonly used type I ecolabels are the EU Ecolabel (European Commission, 2011), the Nordic Ecolabel (Nordic Ecolabelling, 2011) and Good Environmental Choice (Swedish Society for Nature Conservation, 2011). As an example, the EU Ecolabel for textiles has criteria for a number of chemical substances that are not allowed during specified steps of the production process. For instance, there are restrictions for the use of heavy metals, azo dyes, formaldehyde and plasticizers (European Commission, 2009). Considering paint, the EU ecolabel has restrictions on the release of solvents, what pigments that are allowed to be included and that the product does not contain substances that are carcinogenic or toxic (European Commission, 2008a, European Commission, 2008b). Also health labels are common. These labels are provided by certification institutes and organizations and claim that the labelled product is not hazardous for human health. For textiles, the most used health label is Oeko-Tex 100. The responsibility for Oeko-Tex is shared between 17 different test institutes, which together make up the Oeko-Tex Association. In Oeko-Tex 100, the criteria are negotiated on an international level in the association and focused on avoiding risks to human health from textiles. Substances such as pesticides, heavy metals, formaldehyde and allergy-inducing dyestuffs are restricted in the final product (International Association for Research and Testing in the Field of Textile Ecology, 2009). For paint, one common label in Sweden says that the product is recommended by the Swedish organization for the asthmatic and allergic. The organization has a panel of experts reviewing products in order to examine whether they can be recommended or not. The most important criteria for this label are that the product shall not contain perfume, allergenic substances or irritating substances (Astma- och Allergiförbundet, 2011). Another type of label are the so called multilevel labels, such as the EU Energy label (European Commission, 1992) with different levels (A+++ to G) depending on how energy-demanding a product is.

Environmental product declarations (ISO 14025, 2006) were developed in order to make it easier for companies to communicate environmental information to other companies. They are based on LCAs and present quantified environmental data for products and may also be complemented by other types of environmental information. EPDs are declarations of the environmental data and do not include statements considering whether a product is preferable from an environmental perspective (Baumann and Tillman, 2004).

3 Method

In the studies two different industries have been examined and the research question has been to describe “how” and “which” chemical risk information is handled in the different steps of the product chains. There has not yet been much research done in this particular field of study, even though there are some studies in related fields (Forman and Jørgensen, 2004, Erlandsson, 2007, Kogg, 2009, Leire, 2009) and Seuring (2008) has pointed out the need for more case studies including several parts of a supply chain. Based on the facts above, a case study research design was chosen (Meyer, 2001, Yin, 2003, Baxter and Jack, 2008).

Three case studies, concerning two consumer products were made. Consumer products were chosen since private consumers in general, opposite to professional customers, do not have detailed knowledge about chemical risks. The two products chosen for the case studies were textile and paint. Both products have been discussed in media considering their impact on human health and the environment and the legislation concerning them is considerably different, making it interesting to compare the two cases.

The main method for data collection has been semi-structured interviews with open-ended questions, but also short structured interviews have been used (Gillham, 2005). In addition, documents, such as annual reports, SDSs, environmental reports and the companies’ web pages have been studied. The research is empirically based and for analysis of the gathered interview material, content analysis have been used (Mayring, 2000). First, analysis categories have been worked out based on the research question and the knowledge in the field. Then, the material has been worked through step by step and classified into the pre-defined analysis categories. The process has been iterative and the categories have been revised based on the content of the interview material, building up an understanding of how the flows of chemical risk information are functioning.

An important aspect of the research method has been the chain perspective, resulting in the use of concepts such as sustainable supply chain management and product chains in the case studies. A reason for this is that activities where chemicals are used may occur in many parts of a supply/product chain of a consumer product. Furthermore, the chain perspective with chemical risk information communicated both up- and down-stream is central in REACH.

4 Case studies

In the following sections, background and methods for the case studies, conducted in two studied industries are described.

4.1 Textile

In Paper I and II, the case of chemical risk information in a textile supply chain has been investigated. For several years, the issue of chemicals in textiles has been frequently appearing in media (Permell, 1994, Bjers, 2001, Falk, 2007, Gustafsson, 2007, Ekstrand and Grahn, 2008b, Johannisson, 2008, Grahn, 2009, Satz, 2011, Grahn, 2011). There has been a number of studies from NGOs reporting on the presence of hazardous chemicals in clothes and other textiles from, for instance, the Swedish Society for Nature Conservation (Hök, 2007, Prevodnik, 2008a, Prevodnik, 2008b, Engvall, 2008) and Greenpeace (Pedersen and Hartmann, 2004, Greenpeace International, 2011a, Greenpeace International, 2011b). In addition, the Swedish Chemicals Agency (1997) and research institutes (Olsson et al., 2009) as well as research funding agencies (Chapman, 2010) have given attention to problems related to chemicals in textiles. The repeated studies and findings of hazardous chemicals indicate a problem related to the management of chemicals in this industry with many possible reasons. For example, one aspect is that retailers do not make enough tests to verify that their suppliers follow their requests concerning chemicals and it is also possible that retailers are not interested in which chemicals that are used for production and left in the textile. Chemicals providing the same function may have different hazardous properties and different prices and it is possible that some manufacturers prefer the chemical with the lower price without considering the potential risks. In addition, the findings of hazardous chemicals in textiles may be an indication of problems concerning the communication of chemical risk information.

One aspect to have in mind concerning textiles is that they are regarded as “articles” under REACH. This means that the legal requirements considering chemicals for textiles imported to the EU are very low. Furthermore, textiles are wide-spread among consumers, with everyday uses such as clothing, bed-linen and towels. Another aspect of textiles is that nowadays, most of the textiles used in Europe are produced in other countries, even though the retailers may be located in Europe.

4.1.1 Background

Textiles are produced in several steps and a conceptual model of the textile production process can be seen in Figure 6. The production steps where most chemicals are used are fibre production in the form of cotton cultivation and wet treatment processes such as dyeing and printing. Other types of chemical demanding wet processes are used for giving the cloth specific functions, such as crease resistance and dirt repellence.

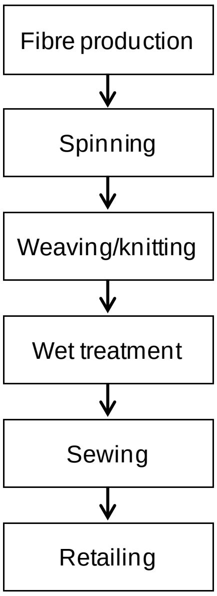

Figure 6. A simplified model of textile production, from fibre production to retailing (European Commission, 2003).

4.1.2 Case study method

Paper I describes a case study on chemical risk information in the textile industry. The study is focused on the communication between retailing companies in Sweden and their suppliers, which are often located in Asian countries such as China, India, Bangladesh and Pakistan. In the case study, semi-structured interviews have been conducted with representatives from textile retailers, authorities and one NGO (see Table 1).

In Paper II, the case has been extended to include also Chinese suppliers and sub-suppliers for two of the Swedish retailers included in Paper I. This extension is based on a master thesis project (Zhang, 2009). Since the retailer (the focal company) is in focus, a supply chain perspective has been used, meaning that no consumers or waste handlers have been interviewed. An addition to the supply chain perspective is the inclusion of external actors, such as authorities and one NGO. A limitation to the studies is that only a few other actors in the textile supply chain have been covered. This is mainly because of difficulties in identifying and finding respondents willing to participate in the study further up-stream the supply chain due to both geographical and confidentiality reasons. The consequential low number of manufacturing companies is a limitation to the study together with the fact that no chemical producer is interviewed. Another limitation is that the retailing companies that accepted to participate in the study (7 out of 16) may be more environmentally ambitious than the ones that rejected to participate.

Table 1. An overview of the respondents in the textile studies, including details on the interviews.

Type of actor	Type of interview	Approximate length of interview	How data was gathered
7 textile retailers (in total 9 respondents)	Semi-structured (one e-mail interview)	1 hour	Recording
2 authorities, 1 NGO	Semi-structured	1 hour	Recording
2 Chinese sewing factories	Semi-structured	1-2 hours	Recording
3 Chinese dyeing and/or printing factories	Semi-structured	1-2 hours	Recording

4.2 Consumer paint

For the second case study, more thoroughly described in Paper III, the paint industry was chosen as the object of study.

Paint has been given attention for its adverse consequences on human health and the environment (Hall Jr et al., 1999, Armstrong et al., 2000, Jacobson and Willingham, 2000, Thomas et al., 2003, Konstantinou and Albanis, 2004, Choi et al., 2010) and health risks connected to paint have been given attention in media over the years (Svensson, 1994, Heyman, 1996, Höglund, 1997, Sjögren, 2010). Furthermore, paint is one of the most complex chemical products available for consumers (Talbert, 2008), which makes it interesting to include the consumer perspective on chemical risk information.

In REACH, paint is regarded as a preparation, which means that there are more regulations concerning chemical risk information than for articles. This is important for this thesis since one of the aims is to describe the differences in chemical risk information related to legislation. Another interesting aspect of the paint case is that paint intended for the Swedish consumer market is mainly produced in Sweden, making it different from textiles. In addition, paint is a product that has undergone large changes regarding its composition during the time period from 1990 to 2010, going from being mostly based on organic solvents to mostly being water-borne (Swedish Chemicals Agency, 2011b). In Sweden, this change was driven by the national painters' union due to health problems among professional painters (Hollander, 1995). It is most probable that the acute risks to human health has decreased due to the change of main solvent, but potential effects due to the increase of the number of chemical substances in paint is still unclear. The shift in main solvent has changed the chemical composition of paint and also been a contributing factor to the large increase of the number of chemicals used in paint production.

4.2.1 Background

Liquid paint consists of the components resins, pigments, solvents and additives (Figure 7) (Lambourne, 1999, Talbert, 2008).

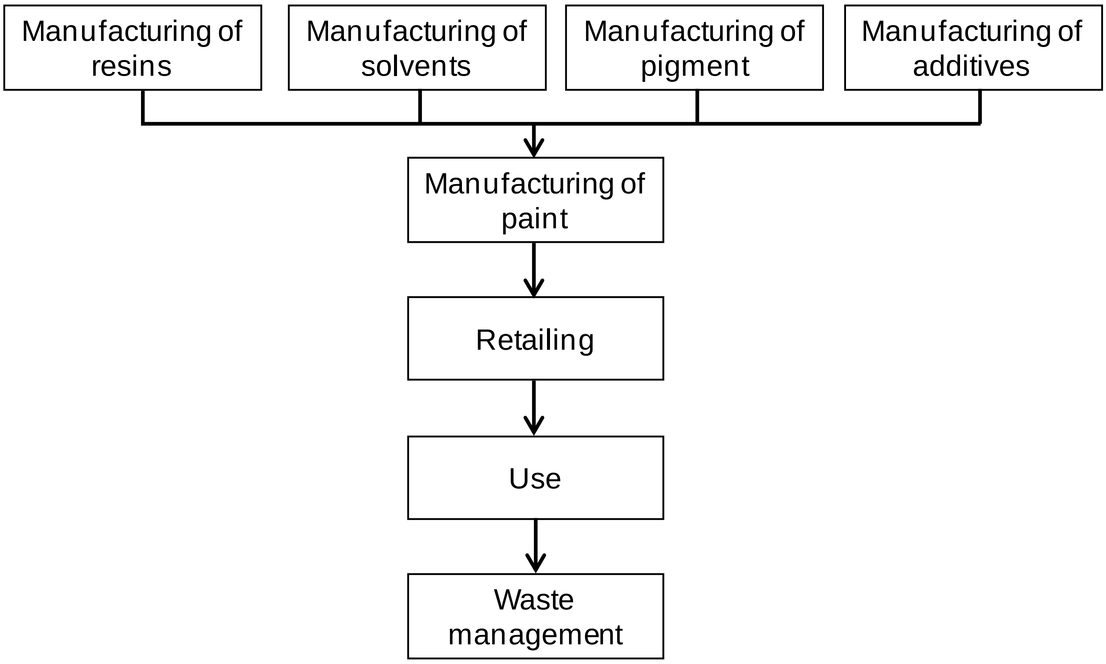

Figure 7. An illustration of the paint product chain, including the main ingredients.

The resin (or binder) is the component of the paint that forms the film and the paint is often named after the type of resin (e.g. alkyd, acrylic or oil paint). The function of the solvent in paint is to make it liquid before application and some examples of solvents are water, alcohols, ketones, ethers, esters and aromatic hydrocarbons. Pigments are used to provide certain characteristics to the paint, such as colour, opacity, durability and mechanical strength. The pigments are particulate solids, which are dispersed in the paint. Examples of white pigments are titanium dioxide and zinc oxide. Additives are normally added to paint in small quantities in order to achieve special effects and adjust properties such as viscosity, pigment dispersion and UV resistance.

According to statistics from the Swedish Chemicals Agency and Statistics Sweden (2011), the annual sale of consumer paint in Sweden in 2009 was 9.5 kg/capita and 22% of this paint was classified as hazardous to the environment. There are no public statistics on how much of the paint used in Sweden that is produced nationally, but according to Statistics Sweden (2011a, 2011b), the export of paint is more than twice as large as the import of paint, indicating that much of the paint consumed in Sweden also is produced there.

4.2.2 Case study method

For the consumer paint case, actors from all parts of the product chain, from chemical producer to waste handlers, were included in order to describe the flows of chemical risk information. However, most focus has been put on the paint manufacturers, since they are producing the final product. An overview of the respondents and the interviews in the study can be seen in Table 2. Since there was an aim to include also actors not involved in the production process, such as consumers and waste handlers, a product chain perspective has been used. In addition, external actors such as the industry organization and the Swedish Chemicals Agency have been included in the study.

Table 2. An overview of the respondents in the paint study, including details on the interviews.

Type of actor	Type of interview	Approximate length of interview	How data was gathered
8 Paint manufacturers	Semi-structured	1 hour	Recording
1 Chemical manufacturer (2 respondents)	Semi-structured	1 hour	Notes were taken
19 Paint retailers	Short structured, via telephone	<5 minutes	Recording
27 Consumers	Short structured	<5 minutes	Notes were taken
1 Industry organization	Semi-structured	1 hour	Recording
1 Swedish Chemicals Agency	E-mail communication	-	-
1 Waste-water treatment plant	E-mail communication	-	-
1 Waste management company	E-mail communication	-	-

5 Results

One of the aims with the thesis is to investigate differences and similarities regarding chemical risk information between the two studied consumer products and relate them to external factors. When doing this, it is important to have in mind that the system boundaries in the case studies have been different (see Figure 8). The textile case only includes actors from the pre-consumption parts of the product chain, from dyeing/printing factories to retailers. The paint case includes actors from the whole product chain, with actors spanning from chemical production to waste management. In addition, both product chains include some external actors. However, a product chain for textile is in general more globalized than for paint, making it interesting to give attention to the linkages between retailers in Sweden and producers in Asia. In addition, paint for consumer use is a preparation according to REACH with more standardized ways of providing down-stream users with chemical risk information. Furthermore, there is a large difference in the role of chemicals in the product chains. In the paint case, chemicals are the main ingredients and crucial for the final product. Textiles are not chemical preparations, although chemical preparations are necessary for the production of textiles.

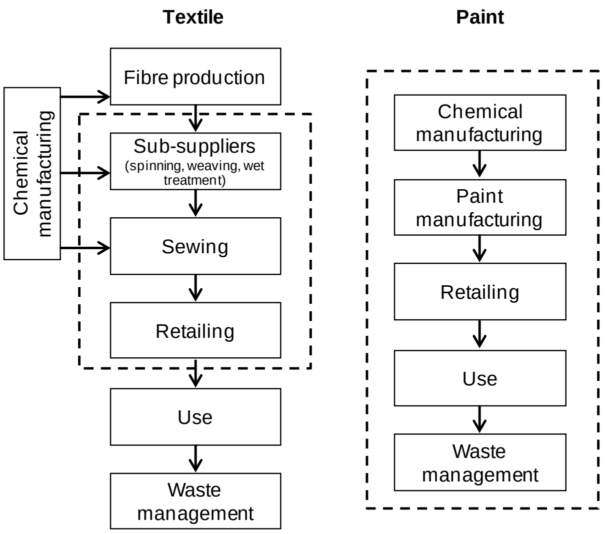

Figure 8. The system boundaries for the two cases textile and paint are marked with dotted lines. As can be seen, the textile case only include the actors involved in production, ending at retailing while the paint case includes actors from all parts of the product chain.

There are large differences between the two studied industries regarding what information that is transferred in the product chains, but also similarities considering the importance of communication with representatives from other companies in the industries and the perceived disinterest from consumers. A summary of the results is given in Table 3.

Table 3 A compilation of how chemical risk information is handled between different actors in the product chains. The results are obtained from the case studies on textiles and paint. When no information has been available, this is indicated with n.a and when the actor is irrelevant for a specific case it is indicated with - . Sub-suppliers stand for actors such as dyeing and printing mills in the textile industry. Intermediate producers of chemical preparations intended for paint production are not included in the table.

	Direction of existing information flow	Textile	Paint
Chemical manufacturer	Down-stream	Instructions on how to use and store the chemicals	SDSs, hazard pictograms, exposure scenarios
	To authorities	n.a.	Registration data to European Chemicals Agency, reporting to the Chemicals Agency's product register, information to municipality or county administration concerning factory permissions
	From authorities	n.a.	Information on new legislation, factory permissions
	Industry-internal	n.a.	Information from industry organization on new legislation Exchange of registration information in SIEFs
	Factory-internal	n.a.	SDS Simplified risk information
Sub-supplier	Down-stream	Commitment to follow the product manufacturer's list of restricted substances	-
Product manufacturer	Up-stream	List of restricted substances	Occasional requests for additional information on the composition of chemical products
	Down-stream	Results from laboratory tests, Commitment to follow list of restricted substances Labelling	SDSs, Environmental Product Declarations, hazard pictograms, labelling
	To authorities	n.a.	Registration data to European Chemicals Agency, reporting to the Chemicals Agency's product register, information to municipality or county administration concerning factory permissions
	From authorities	Environmental regulations Regulations regarding work environment	Information on new environmental and chemical legislation, factory permissions, environmental regulations, regulations regarding work environment
	Industry-internal	n.a.	Interpretation of legislation and industry-internal agreements in cooperation with the industry organization, information from industry organization on new legislation
	Factory-internal	n.a.	SDS Simplified risk information
Retailer	Up-stream	List of restricted substances, training and seminars	Occasional questions
	Down-stream	Labelling	Answers to customers' questions. Product-specific information is already available on the cans
	Industry-internal	Discussions and information about chemicals in industry-specific network, suggestions for substances to be included on the list of restricted substances from industry organization	n.a.
Private consumer	Up-stream	Occasional questions concerning health risks	Occasional questions concerning health risks
Waste management	Up-stream	n.a.	Information on how to handle paint leftovers

For textile, the most extensive set of chemical risk information are the restricted substances lists, distributed up-stream in the supply chain from Swedish retailers to Asian manufacturers. This type of restrictions generally goes beyond local legislation in the producing countries. The industry organization for the Swedish textile retailers, the Textile Importer’s Association in Sweden is considered important, especially for providing a “Guide to buying terms” (The Textile Importer's Association in Sweden, 2003), containing substances recommended to be included on the restricted substances list. However, the most important forum for communication with colleagues among other textile importers is the so called “Chemicals group” at the research centre Swerea IVF (2011). In this group, members representing textile producing and textile retailing companies meet to discuss and achieve information on issues related to chemicals in textiles. Other important external actors are media and NGOs since they have given attention to the risks associated to chemicals in textiles, thus putting pressure on companies to improve their compliance routines. The general view among the representatives from the retailers considering consumers is that they almost only ask for chemical risk information when health risks related to chemicals in textiles have been given attention in media. The most common way for private consumers to obtain risk information for textiles is through labelling, and the most common label is the health label Oeko-Tex 100.

Regarding paint, much information is handled early in the product chain and distributed down-stream. The appearance of the information is standardized in the form of, for instance, SDSs, CSAs, exposure scenarios and hazard pictograms. There is also a requirement for paint manufacturers to register chemicals they use for production in the Swedish Chemicals Agency’s product register (2011d). The industry organization (The Swedish Paint and Printing Ink Makers Association) is considered an important platform for communication with representatives from other manufacturers. In the organization, issues such as interpretation of REACH, SDSs and labelling are discussed, and the organization is also considered important for communication with authorities such as the Swedish Chemicals Agency. There has been some media reporting about chemical risks related to paint, but according to the interviewees representing paint manufacturers, the response from customers has been low compared to the response when media reports about quality tests of paint. According to the representatives from paint manufacturers and retailers, private consumers in general do not show any interest in chemical risk information, and if they do, they normally ask for paint with an environmental or health label.

6 Discussion

The main differences regarding the communication of chemical risks between the two cases presented in the study are the structure, quantity and direction of information. In the paint product chain, the main information flow is directed down-stream and structured in a standardized way in the form of, for instance, hazard pictograms and SDSs. Most of the information is public and available for all actors in the product chain even though it may be almost impossible for actors handling, for instance, demolition waste or waste-water to identify exactly what product they are dealing with. In the textile product chain, the main flow of chemical risk information is in the form of a restricted substances list, communicated up-stream from Swedish textile retailers to Asian textile producers. The response from the manufacturers is that they agree to follow these requirements. Standardized information, such as SDSs is often lacking at the producers and there is a risk for misinterpretation of the requirements from the retailers when information is translated and communicated to sub-suppliers. The need for translation of information is clearly an effect of globalization and it is necessary for Swedish retailers to make sure that their requirements are correctly understood. The differences in how chemical risk information is communicated for the two products can be associated to differences in legislation. One aspect of this is that textiles sold in the EU often are produced in Asian countries, such as China, India and Bangladesh (European Commission, 2010). In these countries, the local environmental legislation is often weak and not fully implemented (Rooij, 2006, Beyer, 2006) while paint in this case is produced in Sweden, where chemical regulations are more stringent and have been implemented for long time (Johannesson et al., 1999, European Commission, 2004, Swedish Chemicals Agency, 2005, European Commission, 2006). According to the interviewees, there are also differences regarding the education-level among the people handling the products and the environmental ambitions among companies in Asia and Europe. This could be due to the higher level of development in Europe.

Another aspect considering legislation is that textile is considered an article under REACH while paint is considered a preparation (EU, 2006). Thus the legislation differs a lot concerning which information that is legally required to be communicated for the different products. Articles, such as textiles imported to the EU seldom need to comply with any requirements in REACH, which in practice means that all responsibility for chemical risk management is laid on the importing retailer companies. As a measure to handle this problem, it has been suggested that regulations for chemicals in articles should be included in REACH, thus making the import of articles containing chemicals to the EU more controlled (Rudén and Hansson, 2010, Swedish Chemicals Agency, 2011a). The difficulties of handling chemical risks for different actors in a global supply chain have been emphasized by Massey et al. (2008) in a number of case studies. They suggest a global system for information about substances in articles and list benefits due to such a system for a number of actors, for example companies, workers, consumers and governments. There are only few focal companies which investigate the chemical use in their supply chains thoroughly, in order to obtain knowledge on all chemicals that are being used for production (Scruggs and Ortolano, 2011). Some reasons for this are that it is difficult and expensive to implements such systems. As an effect of globalization, the visibility of environmental impacts due to chemicals used in production processes for textiles has declined in Europe (Moore and Ausley, 2004) reducing the pressure from the public to implement such systems. Today, much of the requirements retailers put on their suppliers are voluntary and according to interviewees in the textile case, many Swedish retailers would prefer if the environmental legislation in the producing countries was more stringent.

While the paint industry is strongly affected by legal regulations, the textile industry is more exposed to pressure from media and NGOs. The intense regulations concerning preparations imply that many of the paint manufacturing companies are on the same level regarding which chemicals they use and which chemicals they have substituted. Media attention regarding chemical-related risks is more on a general level, concerning the whole paint industry, saying that paint may be hazardous in some ways and the attention has declined following the introduction of water-borne paints (Svensson, 1994, Heyman, 1996, Höglund, 1997, Sjögren, 2010). For textiles, the attention in media and from NGOs has often been in the form of chemical analysis of specific substances, such as nonylphenoletoxylates and phthalates in a number of textiles from different retailers (Hök, 2007, Prevodnik, 2008a, Prevodnik, 2008b, Engvall, 2008, Johannisson, 2008, Karlsson and Finnson, 2008, Ekstrand and Grahn, 2008a, Ekstrand and Grahn, 2008b, Grahn, 2009, Grahn, 2011). The increasing media attention and NGO campaigns have contributed to an increasing awareness of chemical risks among many Swedish textile importing companies (Boström et al., 2011) and according to Paper I at least one company has begun to test their products for new substances due to attention in media.

There are also similarities between the studied industries. One of them is the importance of communication with industry colleagues among the companies located in Sweden. Since there often only is one or a few persons working with environment and chemicals at Swedish companies in the industries included in the case studies, there is a perceived need to discuss uncertainties regarding for instance interpretation of regulations with colleagues in the same industry. The importance of networks and expert knowledge in the textile industry is also highlighted by Boström et al. (2011) as a way for company representatives to be sure that they are up-to-date with legal requirements.

Another similarity is the perceived disinterest among consumers concerning chemical risks. According to the interviewees representing paint manufacturers and retailers and textile retailers, private consumers are in general considered to be more interested in aspects such as quality, price and appearance. It has also been suggested that only a small segment (<20%) of the private consumers are interested in buying “green” products (Rex and Baumann, 2007). Considering chemical risk information, one explanation for the disinterest among private consumers is that they consider chemical risk information too technical and thus hard to understand (Hinks et al., 2009). Nevertheless, it is usually hard for private consumers to achieve information about hazardous substances in textiles and other articles, making it difficult for consumers to protect themselves from hazards posed by toxic substances in articles (Massey et al., 2008). There are also indications that many private consumers in Sweden have a perception that the authorities protect them from all bad chemicals (Hansson, 2008).

The results from both cases showed that labelling was often suggested as a good way of informing consumers about the environmental performance of a product. However, the effects of ecolabels have been examined by several authors (Rex and Baumann, 2007, Erskine and Collins, 1997, Dosi and Moretto, 2001) with the results that it is not clear whether they are actually useful or not. Considering textiles, there is also a possibility that the abundance of labels confuse the consumer. Globally, the number of potential ecolabels for textiles exceeds 100 (Ecolabel index, 2012). It has also been suggested that some reasons for the low consumer demand on labelled textiles are that textiles have not been considered as dangerous for the consumer, and that environmental effects from production are not visible since they occur in countries far away from consumers (Grolink AB, 1999). In a study by Grankvist et al. (2004), it was found that a more effective way of encouraging private consumers to buy products with less negative environmental impact is through the use of negative or multi-levelled environmental labels. If all actors on the market accepted or was forced to have such a label, it is possible that problems connected to hazardous chemicals in consumer products would decrease.

7 Conclusions

In this thesis, the handling and communication of chemical risk information in the product chains of two consumer products has been investigated and described in a Swedish context.

Both differences and similarities were found between the textile and the paint industry. The most profound difference between the two cases was the communication of chemical risk information in the product chains. For the textile case, most information was communicated up-stream between companies, from the retailers to the direct suppliers in the form of a list of restricted substances while for paint, chemical risk information was central in many parts of the product chain, particularly in the manufacturing steps and mainly communicated down-stream between companies.

The existence or lack of implemented legislation is another main difference between the two studied industries. Production of paint and chemical risk information associated to paint are strongly affected both by national legislation and REACH. Much of the information exchanged between producing companies in the paint product chain is regulated. Contrarily, textiles are less affected by legislation since local legislation in producing countries often is less stringent than in Europe and in practice, REACH have little influence over the chemical risk information associated to articles, such as textiles. Instead, textile retailers are to a larger extent put under pressure by media and NGOs and might change their management of chemicals with the motivation that they want to avoid negative publicity.

Another important conclusion is that the geographical context matters, both in terms of possible misunderstandings of information due to translation and in terms of local traditions and degree of development in producing countries.

One similarity between the two studied industries is that communication with colleagues from other Swedish companies in the industry was considered important for interpretation of legislation and information exchange regarding chemicals. An additional similarity between the cases was that the perceived interest from private consumers regarding chemicals in the products was low, indicating that consumers in general are seldom concerned about chemical risks related to products. An exception is when people are allergic, pregnant or worried about potential health risks affecting their children.

8 Implications and further studies

One implication for policy is the importance of legislation in order to have clear and transparent chemical risk information. Thus, it would be desirable with more stringent international legislation concerning articles in order to increase the quality of and amount of information connected to them and subsequently decrease chemical risks.

In further studies, it would be interesting to study more actors within the chemical industry. There, questions considering how they work with the construction of chemical risk information needed for registration of substances would be addressed. Another issue, deserving more attention and interesting for further studies is the perception of chemical risk information by workers in factories and stores. In addition, the small study of consumers in this thesis indicates that there is a disinterest among private consumers regarding chemical risk information. In order to verify these indications, more studies on private consumers are necessary. Since the studies in this thesis are limited to private consumers, an extension of the studies to also include professional users would be relevant in order to find differences and similarities regarding chemical risk information depending on user group.

References

ALLANOU, R., HANSEN, B. G. & BILT, Y. V. D. 1999. Public Availability of Data on EU High Production Volume Chemicals. Ispra: European Commission Joint Research Centre Institute for Health and Consumer Protection European Chemicals Bureau.

APPLEGATE, J. 2008. Bridging the Data Gap: Balancing the Supply and Demand for Chemical Information. *Texas Law Review,* 86**,** 1365-1407.

ARMSTRONG, E., BOYD, K. G. & BURGESS, J. G. 2000. Prevention of marine biofouling using natural compounds from marine organisms.

ASTMA- OCH ALLERGIFÖRBUNDET. 2011. *Svalanmärkt* [Online]. Available: http://www.astmaoallergiforbundet.se/RekProdukter.aspx [Accessed 2011-10-12].

AXELSSON, U., JARNHAMMAR, A., WIDELL, K.-O., JERNBERG, P., JANSSON, G., ZACKRISSIN, M. & HOLMNER, O. 1999. Livscykelanalys av färg. Stockholm: IVL Svenska miljöinstitutet AB.

BAIR, J. 2005. Global Capitalism and Commodity Chains: Looking Back, Going Forward. *Competition & Change,* 9**,** 153-180.

BAUMANN, H. & TILLMAN, A.-M. 2004. *The Hitch Hiker's Guide to LCA,* Lund, Studentlitteratur.

BAXTER, P. & JACK, S. 2008. Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *The Qualitative Report,* 13**,** 544-559.

BEDFORD, T. & COOKE, R. 2001. *Probabilistic Risk Analysis: Foundations and Methods,* New York, Cambridge University Press.

BENGTSSON, G. 2010. Global Trends in Chemicals Management

Regulating Chemical Risks. *In:* ERIKSSON, J., GILEK, M. & RUDÉN, C. (eds.). Springer Netherlands.

BEYER, S. 2006. Environmental Law and Policy in the People's Republic of China. *Chinese Journal of International Law,* 5**,** 185-211.

BJERS, C. M. 2001. Barnjacka innehåller miljögift. Hennes&Mauritz drar tillbaka regnjacka efter tester i Tyskland. *Göteborgs-Posten*, 2001-11-03, p.5.

BOONS, F. 2002. Greening products: A framework for product chain management. *Journal of Cleaner Production,* 10**,** 495-505.

BOONS, F. & MENDOZA, A. 2010. Constructing sustainable palm oil: How actors define sustainability. *Journal of Cleaner Production,* 18**,** 1686-1695.

BOSTRÖM, M., BÖRJESON, N., GILEK, M., JÖNSSON, A. M. & KARLSSON, M. 2011. Towards responsible procurement in relation to chemical risks in textiles? Findings from an interview study. Huddinge: Södertörn University.

BURGMAN, M. 2005. *Risks and Decisions for Conservation and Environmental Management,* Cambridge, Cmbridge University Press.

CARTER, C. R. & ROGERS, D. S. 2008. A framework of sustainable supply chain management: moving toward new theory. *International Journal of Physical Distribution & Logistics Management,* 38**,** 360-387.

CHAPMAN, A. 2010. Mistra Future Fashion - Review of Life Cycle Assessments of Clothing. Aylesbury: Oakdene Hollins Research & Consulting.

CHECKLAND, P. & HOLLOWELL, S. 1998. *Information, Systems and Information Systems,* Chichester, John Wiley and sons Ltd.

CHEMICAL ABSTRACTS SERVICE 2008. Statistical Summary 1907-2007. Columbus, OH.

CHEMICAL ABSTRACTS SERVICE. 2012. *CAS - A division of the American Chemical Society* [Online]. Available: www.cas.org/ [Accessed 2012-01-11].

CHEMITECS. 2012. *ChEmiTechs - Organic Chemicals Emitted from Technosphere Articles* [Online]. [Accessed 2012-01-22 2012].

CHOI, H., SCHMIDBAUER, N., SUNDELL, J., HASSELGREN, M., SPENGLER, J. & BORNEHAG, C.-G. 2010. Common Household Chemicals and the Allergy Risks in Pre-School Age Children. *PLoS ONE,* 5**,** e13423.

CHOO, C. W. 1996. The Knowing Organization: How Organizations Use Information to Construct Meaning, Create Knowledge and Make Decisions. *International Journal of Information Management*, 16**,** 329-340.
COLBORN, T., DUMANOSKI, D. & MYERS, J. P. 1996. *Our Stolen Future: Are We Threatening Our Fertility, Intelligence, and Survival?: A Scientific Detetctive Story,* New York, Dutton Peguin Books.
COMMISSION OF THE EUROPEAN COMMUNITIES 2001. White Paper: Strategy for a future Chemicals Policy. Brussels: Commission of the European Communities.
COYLE, J. J., BARDI, E. J. & LANGELY, C. J., JR 2003. *The Management of Business Logistics: A Supply Chain Perspective, 7e,* Mason, Ohio, South-Western, Thomson Learning.
DAHLLÖF, L. 2004. *LCA Methodology Issues for Textile Products.* Licentiate of Engineering, Chalmers University of Technology.
DICKEN, P. 1994. The Roepke Lecture in Economic Geography: Global-Local Tensions: Firms and States in the Global Space Economy. *Economic Geography,* 70**,** 101-101.
DOSI, C. & MORETTO, M. 2001. Is ecolabelling a reliable environmental policy measure? *Environmental and Resource Economics,* 18**,** 113-127.
ECOLABEL INDEX. 2012. *All ecolabels on textiles* [Online]. Big Room inc. Available: http://www.ecolabelindex.com/ecolabels/?st=category,textiles [Accessed 2012-01-13 2012].
EKSTRAND, L. & GRAHN, M. 2008a. Borg-kalsonger 08. *Göteborgs-Posten*, 2008-08-13.
EKSTRAND, L. & GRAHN, M. 2008b. Fullt med miljögift i Björn Borg-kalsongerna. *Göteborgs-Posten,* 2008-08-19, p.18.
ENGVALL, M. 2008. Den blinda klädimporten. Stockholm: Swedwatch.
ERLANDSSON, J. 2007. *Determinants of Corporate Environmental Information Management - Analytical Framework and Case Studies.* Licentiate, Chalmers University of Technology.
ERNST, D. & KIM, L. 2002. Global production networks, knowledge diffusion, and local capability formation. *Research Policy,* 31**,** 1417-1429.
ERSKINE, C. C. & COLLINS, L. 1997. Eco-labelling: Success or failure? *Environmentalist*, 17**,** 125-133.
ESTY, D. C. & WINSTON, A. S. 2006. *Green to Gold : How Smart Companies Use Environmental Strategy to Innovate, Create Value, and Build Competitive Advantage,* New Haven, CT, USA, Yale University Press.
EU 2006. Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC
Official Journal of the European Union L396/1: The European Parliament and the council of the European Union.
EUROPEAN CHEMICALS AGENCY. 2011. *Understanding CLP* [Online]. Helsinki. Available: http://echa.europa.eu/web/guest/regulations/clp/understanding-clp [Accessed 2011-12-22 2011].
EUROPEAN COMMISSION 1992. Council Directive 92/75/EEC of 22 September 1992 on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances. Official Journal of the European Communities: European Commission.
EUROPEAN COMMISSION 2003
Integrated Pollution Prevention and Control - Reference Document on Best Available Techniques for the Textiles Industry. Seville.
EUROPEAN COMMISSION 2004. Directive 2004/42/CE of the European Parliament and of the Council. Official Journal of the European Union: European Commission.
EUROPEAN COMMISSION 2006. Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation

and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC
Official Journal of the European Union L396/1: The European Parliament and the council of the European Union.

EUROPEAN COMMISSION 2008a. Commission decision of 13 August 2008 establishing the ecological criteria for the award of the Community eco-label to indoor paint and varnishes. Official Journal of the European Communities: European Commission.

EUROPEAN COMMISSION 2008b. Commission decision of 13 August 2008 establishing the ecological criteria for the award of the Community eco-label to outdoor paint and varnishes. Official Journal of the European Communities: European Commission.

EUROPEAN COMMISSION 2008c. REGULATION (EC) No 1272/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 16 December 2008
on classification, labelling and packaging of substances and mixtures, amending and repealing
Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006. Official Journal of the European Union: European Commission.

EUROPEAN COMMISSION 2009. Commission decision of 9 July 2009 establishing the ecological criteria for the award of the Community Ecolabel for textile products. Official Journal of the European Communities: European Commission.

EUROPEAN COMMISSION. 2010. *Textiles and clothing statistics* [Online]. European Commission. Available: http://ec.europa.eu/enterprise/textile/statistics.htm [Accessed 2010-11-19 2010].

EUROPEAN COMMISSION. 2011. *EU Eclolabel* [Online]. Available: http://ec.europa.eu/environment/ecolabel/index_en.htm [Accessed 2011-10-12].

EUROPEAN ENVIRONMENTAL BUREAU 2010. The Fight to Know? Substances of Very High Concern & The Citizens' Right to Know Under Reach. *In:* SCHAIBLE, C. & BONNEAU, E. (eds.). Brussels: European Environmental Bureau (EEB).

EVANS, P. B. & WURSTER, T. S. 1997. Strategy and the new economics of information. *Harvard business review,* 75**,** 70-82.

FALK, J. 2007. Giftiga handdukar såldes trots förbud. *Dagens Nyheter*, 2007-09-12, p.40.

FORMAN, M. & JØRGENSEN, M. S. 2004. Organising environmental supply chain management. Experience from a sector with frequent product shifts and complex products chains: The case of the Danish Textile sector. *Greener Management International***,** 43-62.

GEREFFI, G. 1994. *Commodity chains and global capitalism*, Praeger.

GEREFFI, G., HUMPHREY, J. & STURGEON, T. 2005. The governance of global value chains. *Review of International Political Economy,* 12**,** 78-104.

GILLHAM, B. 2005. *Interviewing: The range of techniques.*, Berkshire, UK, McGraw-Hill Education.

GOLD, S., SEURING, S. & BESKE, P. 2010. Sustainable supply chain management and inter-organizational resources: A literature review. *Corporate Social Responsibility and Environmental Management,* 17**,** 230-245.

GRAHN, M. 2009. Höga halter gift hittade i flera jeans. *Göteborgs-Posten*, 2009-09-11, p.22.

GRAHN, M. 2011. Cancerframkallande ämne i T-shirt. *Göteborgs-Posten*, 2011-01-15, p.64.

GRANKVIST, G., DAHLSTRAND, U. & BIEL, A. 2004. The Impact of Environmental Labelling on Consumer Preference: Negative vs. Positive Labels. *Journal of Consumer Policy,* 27**,** 213-230.

GREENPEACE INTERNATIONAL 2011a. Dirty Laundry 2: Hung out to Dry. Amsterdam.

GREENPEACE INTERNATIONAL 2011b. Dirty Laundry. Unravelling the corporate connections to toxic water pollution in China. Amsterdam.

GROLINK AB 1999. Miljömärkta Textilier - Underlag för en strategisk analys. Helsingborg: Grolink AB.

GUINÉE, J. B., HEIJUNGS, R., HUPPES, G., ZAMAGNI, A., MASONI, P., BUONAMICI, R., EKVALL, T. & RYDBERG, T. 2011. Life cycle assessment: Past, present, and future. *Environmental Science and Technology,* 45**,** 90-96.

GUSTAFSSON, A. 2007. Barnoveraller innehåller förbjudna giftämnen. *Svenska Dagbladet*, 2007-11-11, p.13.
HALL JR, L. W., GIDDINGS, J. M., SOLOMON, K. R. & BALCOMB, R. 1999. An ecological risk assessment for the use of Irgarol 1051 as an algaecide for antifoulant paints. *Critical Reviews in Toxicology,* 29**,** 367-437.
HANSSON, S. 08-09-17 2008. *RE: County Administration of Västra Götaland, Vänersborg, Sweden.*
HEYMAN, E. 1996. Färger fara för miljö och hälsa. En stor del av innehållet i burken kan vara farlig lacknafta. *Göteborgs-Posten,* 1996-04-23, p.8.
HINKS, J., BUSH, J., ANDRAS, P., GARRATT, J., PIGOTT, G., KENNEDY, A. & PLESS-MULLOLI, T. 2009. Views on chemical safety information and influences on chemical disposal behaviour in the UK. *Science of The Total Environment,* 407**,** 1299-1306.
HOLLANDER, E. 1995. *Varför var det så segt? Om lågriskkemi, miljödriven innovation och kravformning.* Kungliga Tekniska Högskolan.
HOLLANDER, E. 2010. Chinese food for thoughts - A Guest Lectureship in Guangdong combined with visits to Shanghai and Hong Kong. Gävle: Zhuhai College of Jilin University and University of Gävle.
HOLLANDER, E. 2011. The doll, the globe and the boomerang - chemical hazards futures introduced by a doll travelling from China to Sweden. Gaevle: University of Gaevle.
HÖGLUND, J. 1997. Ny färg på huset en miljöfråga. *Göteborgs-Posten*, 1997-07-02, p.22.
HÖK, F. 2007. Handdukar med ett smutsigt förflutet. Stockholm: The Swedish Society for Nature Conservation.
ILES, A. 2007. Identifying environmental health risks in consumer products: Non-governmental organizations and civic epistemologies. *Public Understanding of Science,* 16**,** 371-391.
INTERNATIONAL ASSOCIATION FOR RESEARCH AND TESTING IN THE FIELD OF TEXTILE ECOLOGY 2009. OEKO-TEX Standard 100, General and special conditions. Zürich, Switzerland: International Association for Research and Testing in the Field of Textile Ecology.
ISO 14025 2006. Environmental labels and declarations -- Type III environmental declarations -- Principles and procedures. Geneva: International Organisation for Standardization.
ISO 14040 2006. Environmental Management - Life cycle assessment - Principles and framework. Geneva: International Organisation for Standardization.
ISO 2009. Environmental management - The ISO 14000 family of International Standards. Geneva: International Organisation for Standardization.
JACOBSON, A. H. & WILLINGHAM, G. L. 2000. Sea-nine antifoulant: An environmentally acceptable alternative to organotin antifoulants. *Science of The Total Environment,* 258**,** 103-110.
Submission - in defence of the unborn, 2010. Directed by JARL, S. Sweden: Folkets Bio.
JENKINS, C. L. 1978. Textile dyes are potential hazards. *Journal of Environmental Health,* 40**,** 256-263.
JOHANNESSON, M., HANSSON, S. O., RUDÉN, C. & WINGBORG, M. 1999. Risk management - The Swedish way(s). *Journal of Environmental Management,* 57**,** 267-281.
JOHANNISSON, E. 2008. Miljögift finns i vanliga tröjor. *Svenska Dagbladet*, 2008-09-19, p.17.
KARLSSON, M. & FINNSON, A. 2008. Stadium säljer kläder som förgiftar våra vatten. *Dagens Nyheter*, 2008-04-23.
KLINTMAN, M. 2006. Research application - Towards Impoved Interactions in the Two-Way Flow of Risk-Related Chemical Information - The Cases of Clothing, Toys and Paint. Lund: Research Policy Institute.
KLINTMAN, M. 2009. Participation in Green Consumer Policies: Deliberative Democracy under Wrong Conditions. *Journal of Consumer Policy***,** 43-57.
KLINTMAN, M. & STENBORG, E. 2011. Use-oriented consumer reflexivity: Chemical risk dilemmas surrounding garment maintenance and washing. *Nordic Environmental and Social Science Conference.* Stockholm.
KOGG, B. 2009. *Responsibility in the Supply Chain.* Doctor, Lund University.

KOGG, B. & THIDELL, Å. 2010. Chemicals in Products - An overview of systems for providing information regarding chemicals in products and of stakeholders' needs for such information. Lund.

KONSTANTINOU, I. K. & ALBANIS, T. A. 2004. Worldwide occurrence and effects of antifouling paint booster biocides in the aquatic environment: A review. *Environment International,* 30**,** 235-248.

KRISHNAN, V. 2008. *Antimicrobial and antistatic polymers and methods of using such polymers on various substrates*. US patent application 20080226584

LAMBERT, D. M. & COOPER, M. C. 2000. Issues in Suupply Chain Management. *Industrial Marketing Management,* 29**,** 65-83.

LAMBOURNE, R. 1999. Paint composition and applications - a general introduction. *In:* LAMBOURNE, R. & STRIVENS, T. A. (eds.) *Paint and Surface Coatings - Theory and Practice (2nd Edition).* Cambridge: Woodhead Publishing.

, S. & PLOUFFE, S. 2004. The ecolabel and sustainable development. *International Journal of Life Cycle Assessment,* 9**,** 349-354.

LEGNER, C. & SCHEMM, J. 2008. Toward the Inter-organizational Product Information Supply Chain -- Evidence from the Retail and Consumer Goods Industries. *Journal of the Association for Information Systems,* 9**,** 119-150.

LEIRE, C. 2009. *Increasing the environmental and social sustainability in corporate purchasing.* Doctor, Lund University.

LIPPMANN, S. 1999. Supply Chain Environmental Management: Elements for Success. *Environmental management,* 6**,** 175-182.

MACCARTHY, B. L. & ATTHIRAWONG, W. 2003. Factors affecting location decisions in international operations - A Delphi study. *International Journal of Operations and Production Management,* 23**,** 794-818.

MASSEY, R. I., HUTCHINS, J. G., BECKER, M. & TICKNER, J. 2008. Toxic Substances in Articles: The Need for Information. *In:* NORD, T. (ed.) *TemaNord 2008:596.* Copenhagen: Nordic Council of Ministers.

MAYRING, P. 2000. *Qualitative Content Analysis*.

MEIXELL, M. J. & GARGEYA, V. B. 2005. Global supply chain design: A literature review and critique. *Transportation Research Part E: Logistics and Transportation Review,* 41**,** 531-550.

MEYER, C. B. 2001. A Case in Case Study Methodology. *Field Methods,* 13**,** 329-352.

MOORE, S. B. & AUSLEY, L. W. 2004. Systems thinking and green chemistry in the textile industry: concepts, technologies and benefits. *Journal of Cleaner Production,* 12**,** 585-601.

NAGURNEY, A. 2006. Supply Chain Network Economics: Dynamics of Prices, Flows and Profits. Cheltenham: Edward Elgar Publishing.

NORDIC ECOLABELLING. 2011. *The Nordic Ecolabel* [Online]. Available: http://www.nordic-ecolabel.org/ [Accessed 2011-10-12].

OLSSON, E., POSNER, S., ROOS, S. & WILSON, K. 2009. Kartläggning av kemikalieanvändning i kläder. Mölndal: Swerea IVF.

PAPASAVVA, S., KIA, S., CLAYA, J. & GUNTHER, R. 2001. Characterization of automotive paints: An environmental impact analysis. *Progress in Organic Coatings,* 43**,** 193-206.

PEDERSEN, H. & HARTMANN, J. 2004. Toxic Childrenswear By Disney. Brussels: Greenpeace.

PERMELL, C. 1994. Därför är Björn Borgs kalsonger livsfarliga. *Expressen*, 1994-03-10, p.300.

PONTE, S. 2002. The 'Latte Revolution'? Regulation, markets and consumption in the global coffee chain. *World Development,* 30**,** 1099-1122.

PREVODNIK, A. 2008a. Mjuka tryck med hårda konsekvenser. Stockholm: The Swedish Society for Nature Conservation.

PREVODNIK, A. 2008b. T-shirts with a murky past. Stockholm: The Swedish Society for Nature Conservation.

RAIKES, P., JENSEN, M. F. & PONTE, S. 2000. Global commodity chain analysis and the French filière approach: Comparison and critique. *Economy and Society,* 29**,** 390-417.

RAS, P. J., VERMEULEN, W. J. V. & SAALMINK, S. L. 2007. Greening global product chains: Bridging barriers in the north-south cooperation. An exploratory study of possibilities for improvement in the product chains of table grape and wine connecting South Africa and the Netherlands. *Progress in Industrial Ecology,* 4**,** 401-417.

REBITZER, G., EKVALL, T., FRISCHKNECHT, R., HUNKELER, D., NORRIS, G., RYDBERG, T., SCHMIDT, W. P., SUH, S., WEIDEMA, B. P. & PENNINGTON, D. W. 2004. Life cycle assessment Part 1: Framework, goal and scope definition, inventory analysis, and applications. *Environment International,* 30**,** 701-720.

REX, E. & BAUMANN, H. 2007. Beyond ecolabels: what green marketing can learn from conventional marketing. *Journal of Cleaner Production,* 15**,** 567-576.

ROOIJ, B. V. 2006. Implementation of Chinese Environmental Law: Regular Enforcement and Political Campaigns. *Development and Change,* 37**,** 57-74.

RUDÉN, C. & HANSSON, S. O. 2010. Registration, Evaluation, and Authorization of Chemicals (REACH) is but the first step-how far will it take us? Six further steps to improve the european chemicals legislation. *Environmental Health Perspectives,* 118**,** 6-10.

SATZ, L. 2011. Gifter i kläder. Förbjuden kemikalie i mer än vartannat plagg. *Sydsvenskan,* 2011-08-24, p.22.

SCRUGGS, C. E. & ORTOLANO, L. 2011. Creating safer consumer products: The information challenges companies face. *Environmental Science and Policy,* 14**,** 605-614.

SEURING, S. 2004. Integrated chain management and supply chain management comparative analysis and illustrative cases. *Journal of Cleaner Production,* 12**,** 1059-1071.

SEURING, S. & MÜLLER, M. 2008. From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production,* 16**,** 1699-1710.

SEURING, S. A. 2008. Assessing the rigor of case study research in supply chain management. *Supply Chain Management-an International Journal,* 13**,** 128-137.

SJÖGREN, G. 2010. Kemikalier hälsohot i hemmen. *Dagens Nyheter,* 2010-10-19.

SJÖSTRÖM, J. 2008. Kemi i massmedia. *Kemivärlden Biotech med Kemisk Tidskrift***,** 49.

SJÖSTRÖM, J. 2011. Towards Bildung-Oriented Chemistry Education. *Science and Education***,** 1-18.

SLOVIC, P. 1987. Perception of risk. *Science,* 236**,** 280-285.

SOLÉR, C., BERGSTRÖM, K. & SHANAHAN, H. 2010. Green supply chains and the missing link between environmental information and practice. *Business Strategy and the Environment,* 19**,** 14-25.

STABELL, C. B. & FJELDSTAD, Ø. D. 1998. Configuring value for competitive advantage: On chains, shops, and networks. *Strategic Management Journal,* 19**,** 413-437.

STATISTICS SWEDEN. 2011a. *Handel med varor och tjänster: Varuexport till samtliga länder efter varugrupp KN 5-siffernivå och handelspartner (sekretessrensad). Ej bortfallsjusterat. År 1995-2010* [Online]. Available: http://www.ssd.scb.se/databaser/makro/start.asp [Accessed 2011-10-06].

STATISTICS SWEDEN. 2011b. *Handel med varor och tjänster: Varuimport från samtliga länder efter varugrupp KN 4-siffernivå och handelspartner (sekretessrensad). Ej bortfallsjusterat. År 1995-2010* [Online]. Available: http://www.ssd.scb.se/databaser/makro/start.asp [Accessed 2011-10-06].

STEINBERGER, J., FRIOT, D., JOLLIET, O. & ERKMAN, S. 2009. A spatially explicit life cycle inventory of the global textile chain. *The International Journal of Life Cycle Assessment,* 14**,** 443-455.

STENBORG, E. 2010. *The framing of chemical risks in media - A case study of consumer goods.* Half-time draft of PhD-manuscript, Lund University.

STENBORG, E. & KLINTMAN, M. 2011. A local environmental organization's efforts to influence the decision-making process of a large-scale research facility: LNF and ESS. *Manuscript to be published in: Anthology on European Spallation Source (ESS).*

STRATEGIC APPROACH TO INTERNATIONAL CHEMICALS MANAGEMENT (SAICM). 2012. *Strategic approach to International Chemicals Management (SAICM)* [Online]. Available: http://www.saicm.org [Accessed 2012-01-04].

STROMBERG, L. 2004. Integrated life-cycle design of coatings on exterior wood. Part 2: Life-cycle assessment. *Surface Coatings International Part B: Coatings Transactions,* 87**,** 211-220.
SWEDISH CHEMICALS AGENCY 2005. Kemikalieinspektionens författningssamling KIFS 2005:7 *In:* SWEDISH CHEMICALS AGENCY (ed.).
SWEDISH CHEMICALS AGENCY 2011a. Action plan for a toxic-free everyday environment English summary of a government assignment. Sundbyberg: Swedish Chemicls Agency.
SWEDISH CHEMICALS AGENCY. 2011b. *KemI-stat* [Online]. Available: http://apps.kemi.se/kemistat/ [Accessed 2011-02-23 2011].
SWEDISH CHEMICALS AGENCY 2011c. Kemikalier i varor. Sundbyberg.
SWEDISH CHEMICALS AGENCY. 2011d. *Products Register* [Online]. Available: www.kemi.se/templates/Page____2972.aspx [Accessed 2011-11-23].
SWEDISH CHEMICALS AGENCY & STATISTICS SWEDEN 2011. Miljö- och hälsofarliga kemikalier 2009 Ämnen och produkter Hazardous chemicals. *Sveriges officiella statistik statistiska meddelanden MI45SM1101.* Stockholm.
SWEDISH SOCIETY FOR NATURE CONSERVATION. 2011. *Good Environmental Choice* [Online]. Available: http://www.naturskyddsforeningen.se/bra-miljoval/in-english/about-bra-miljoval/ [Accessed 2011-10-12].
SVENDING, O. 2003. *Industrial Management of Environmental Data - Suggested procedures for internal allocation based on stakeholder needs.* Licentiate, Chalmers University of Technology.
SVENSSON, G. 2007. Aspects of sustainable supply chain management (SSCM): conceptual framework and empirical example. *Supply Chain Management: An International Journal,* 12**,** 262-266.
SVENSSON, P. 1994. Färgen gav skador för livet. Nu varnar Valdemar sina yngre kolleger för gifterna. *Göteborgs-Posten*, 1994-12-23, p.6.
SWEREA IVF AB. 2011. *Kemikaliegruppen vid Swerea IVF* [Online]. Available: http://extra.ivf.se/kemi/ [Accessed 2011-10-18 2011].
TALBERT, R. 2008. *Paint technology handbook,* Boca Raton, Florida, CRC Press
Taylor and Francis group, LLC.
TEUSCHER, P., GRÜNINGER, B. & FERDINAND, N. 2005. Risk Management in Sustainable Supply Chain Management (SSCM): Lessons Learnt from the Case of GMO-Free Soybeans. *Corporate Social Responsibiliy and Environmental Management,* 13**,** 1-10.
THE SWEDISH NATIONAL CHEMICALS INSPECTORATE 1997. Chemicals in textiles. Solna: The Swedish National Chemicals Inspectorate.
THE TEXTILE IMPORTER'S ASSOCIATION IN SWEDEN 2003. Guide to buying terms for the chemical content in textiles, clothing, leather goods and shoes. Stockholm: The Textile Importer's Association in Sweden.
THOMAS, K. V., MCHUGH, M., HILTON, M. & WALDOCK, M. 2003. Increased persistence of antifouling paint biocides when associated with paint particles. *Environmental Pollution,* 123**,** 153-161.
TRUDEL, D., SCHERINGER, M., VON GOETZ, N. & HUNGERBÜHLER, K. 2011. Total consumer exposure to polybrominated diphenyl ethers in north america and europe. *Environmental Science and Technology,* 45**,** 2391-2397.
UNITED NATIONS 2009. Globally Harmonized System of Classification and Labelling of Chemicals (GHS). *In:* UNITED NATIONS (ed.) 3d ed. New York and Geneva.
UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE. 2012. *GHS Pictograms* [Online]. Available: http://www.unece.org/trans/danger/publi/ghs/pictograms.html [Accessed 2012-01-17].
UNITED NATIONS INSTITUTE FOR TRAINING AND RESEARCH 2008. Understanding the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). *In:* UNITAR (ed.). Geneva, Switzerland: Chemicals and Waste Management Programme.
US ENVIRONMENTAL PROTECTION AGENCY 2002. Toxic Substances Control Act. *In:* US ENVIRONMENTAL PROTECTION AGENCY (ed.).

US EPA 1998. Guidelines for Ecological Risk Assessment. Washington DC.
VAN LEEUWEN, C. J. & VERMEIRE, T. G. (eds.) 2007. *Risk Assessment of Chemicals: An Introduction,* Dordrecht: Springer.
WENDIN, M. 2007. Underlag för miljöstrategi för DEM Collective - Livscykelanalys av t-shirt 2006. Göteborg: Miljögiraff.
VERMEULEN, W. J. & RAS, P. J. 2006. The challenge of greening global product chains: Meeting both ends. *Sustainable Development,* 14**,** 245-256.
YIN, R. K. 2003. *Case study research: design and methods,* Thousand Oaks, California, Sage Publications, Inc.
ZHANG, Y. 2009. Chemical Information in two Textile Supply Chains - A case study of producers in China. Gothenburg: Chalmers University of Technology.