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Themes and challenges in developing sustainable supply chains

Towards a complexity theory perspective

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Licentiate thesis

Themes and challenges in developing sustainable supply chains

Towards a complexity theory perspective

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Dedicated to my supervisors and parents

You were my eyes when I couldn't see
You were my voice when I couldn't speak
You were my hands when I couldn't write …

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To create scientific knowledge and solve problems has been my greatest wish since childhood. Both of these require research. However, research is RE-search! It calls for searching and searching AGAIN. The challenge is to search the path again and again as it is not clear and ready at the beginning of the research journey.

I dedicate this thesis to my main supervisor, Fredrik Nilsson, who has stood beside me in all uphill and downhill stages of this research journey. I have had the honor and opportunity of being the student of this friendly, humble, charismatic, and visionary leader! I will never forget your endless patience, support, and encouragement when I started to learn how to write academically, work scientifically, and speak Swedish. And a special thanks for the supervision meetings at Espresso House restaurants when you were on parental leave.

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Last but by no means least; I dedicate this work to my family. My parents, elder brother and his wife, and younger brother have all motivated and supported me in every stage of my life. I am grateful for your trust and belief in me! I love you all!

25 April 2012, Lund, Sweden
Maisam Abbasi

Abstract

Sustainable development is one of the greatest global challenges facing human beings in the 21st century. In order to tackle sustainability related problems, several global, European, and national targets for 2050 have been set. The transition of supply chains activities towards sustainability targets calls for designing new strategies and continuously identifying and tackling the challenges that can hinder the operationalization of such strategies.

The purpose of this research was to explore and classify themes and challenges in developing sustainable supply chains activities in general, and freight transport and urban distribution in particular. Three research questions were defined followed by defining the scientific assumptions and research strategies. Three research studies were then designed and carried out to find trustworthy and authentic answers to the corresponding research questions. However, research design, data collection, and data analysis were mixed and overlapping as they were not completely sequentially carried out. Data were collected by triangulation of different research methods, namely, literature review, content analysis, and semi-structured interviews. Analysis of the data was guided by principles of content analysis, discourse analysis, analytic induction, and grounded theory. Synthesis of the analyzed data resulted in the emergence of categories of themes and challenges, the development of hypotheses, and further discussion.

In total, five categories of themes were identified for making supply chains environmentally sustainable, fifteen for making freight transport sustainable, and eight for making urban freight distribution sustainable. Five categories of challenges were identified for making supply chains environmentally sustainable, five for making freight transport sustainable, and seven for making urban freight distribution sustainable. All the themes and challenges were then synthesized to determine the patterns of their association. Five major themes in developing sustainable supply chains emerged, namely, increasing sustainability awareness, closing the loop of supply chains, making supply chains energy-efficient, making supply chains environmentally responsible, and managerial issues. Five major challenges in developing sustainable supply chains emerged, namely, change of behavior, costs, implementation, corporate governance, and antagonistic effects and paradoxical conflicts.

As the nature of supply chains and the challenges identified in developing them sustainably is complex, a complexity theory perspective was considered beneficial for dealing with them. Such a perspective can enable us to: take a more holistic view of available sustainability-oriented strategies and activities; analyze the antagonistic effects of strategies and activities on each other; recognize conflicts of a paradoxical character that exist in supply chains; analyze the changes influencing and influenced by the strategies and activities; appreciate enough diversity and freedom among the sub-systems rather than too much simplification of them; design and redesign the transition paths for different types of supply chains.

A complexity theory perspective can also be beneficial when governing a transformative transition of supply chains towards sustainability targets. Lessons are suggested in the discussion chapter that may help policy and decision makers in designing the future strategies and in tackling the challenges. The themes identified can be beneficial for increasing the absorptive capacity of industries, practitioners, and policy makers while they design innovative strategies for transitions towards sustainability targets. The identified challenges can also be beneficial for reducing the inertia and uncertainties against operationalization of sustainable development in practice.

List of appended papers

Paper I

Title: Themes and challenges in making supply chains environmentally sustainable
Authors: Maisam Abbasi and Fredrik Nilsson
Published in: Supply Chain Management: An International Journal
Presented at: NOFOMA 2010 Conference, Kolding, Denmark

This paper has been accepted for publication in *Supply Chain Management: An International Journal*. An earlier version of the paper was presented at the NOFOMA 2010 Conference, Kolding, Denmark.

Paper II

Title: Themes and challenges in making freight transport sustainable
Authors: Maisam Abbasi and Fredrik Nilsson
Published in: Transportation Research Forum Conference Proceeding, – Florida, – USA
Presented at: NOFOMA 2011 Conference, Harstad, Norway

This paper has been accepted for publication in the *Transportation Research Forum Conference Proceedings*. An earlier version of the paper was presented at the NOFOMA 2011 Conference, Harstad, Norway.

Paper III

Title: Themes and challenges in making urban freight distribution sustainable
Authors: Maisam Abbasi and Mats Johnsson
Published in: Øresund Ecomobility Project book
Presented at: NOFOMA 2012 Conference, Turku, Finland

An earlier version of this paper was published as a chapter in the Øresund Ecomobility Project book, *Rethinking transport in the Øresund Region* (chapter 6, p. 93-112). It is available online at http://www.oresundecomobility.org/news/news-2012/news-items-as-widgets/ecomobility-the-book.

A later version of the paper will be presented at the NOFOMA 2012 Conference, Turku, Finland in June 2012.

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1. INTRODUCTION

"The process of scientific discovery is, in effect, a continual flight from wonder."

Albert Einstein

This chapter provides a holistic view of the background, purpose, and framework of the research. Brief descriptions of the practical problems that have motivated the research questions are introduced followed by a summary of research studies and projects.

1.1 Background

Industries have shown radical patterns of development since the Industrial Revolution (the last two centuries of the 46 million centuries of the age of the earth and of the 40 million centuries of life [Löther, 2008]). Advancements in machinery, working conditions, services, technologies (especially information and communication technologies [ICT] after information revolution), and business models are just a few examples.

In recent decades, industries have determined that by managing their intra- and inter relationships (i.e. supply/value chains), they can increase the efficiency of their operations, optimize utilization of resources, decrease transactional and total costs, fulfill their networks' values, better match supply with demand, and design more competitive business models.

However, even more recently, some industries have realized that these developments have evolved in an unsustainable direction. Sustainable development encompasses all the interdependent and mutually reinforcing pillars of economic development, social development, and environmental protection (United Nations World Summit, 2005).

While financially feasible, industrial activities are still enormously dependent on non-renewable sources of energy. They are exponentially depleting and wasting natural resources, and are performed according to unethical laws and standards. In addition, industrial activities have several negative impacts on both the natural environment and society. Some examples are pollution, emissions, noise, congestion, injuries, accidents, visual intrusion, land-take, deteriorating cultural carrying capacity (Hardin, 1991), vibration, negative effects on residents' health and safety, and waste disposal. The natural environment and society also have a negative impact on industrial activities and supply chains. Natural disasters (like floods, earthquakes, volcanic eruptions, and tornados), rust, corrosion, sudden temperature changes, shock, stress, cargo theft, smuggling of goods, and hi-jacking are just some of the negative effects.

Transforming the development of supply chains towards sustainability is tied to the world-class challenges identified in this research, such as business logic, complexity, socio-political interests, and paradoxical conflicts.

1. One challenge is to break the current business logic where all pillars of sustainable development are sacrificed for short-term financial sustainability. This logic has led to an "*earning without paying"* perspective in several industries for several decades. From this perspective, it is acceptable to do business only to make a monetary profit without paying attention or money for environmental degradation and social vulnerability. It is tremendously challenging to develop new business models and logic where all corporate social responsibility principles of sustainable development (chapter 3) become as important as monetary profitability.

2. A second challenge is the increasing complexity of supply chains in their evolution (Nilsson, 2005; Abbasi, 2008). These involve among others:
   - increasing transportation and distribution of goods due to economic growth
   - increasing consumption and demand for goods and services due to population growth and purchasing power of middle class consumers
   - increasing number of products and bill of materials (BOM) due to market diversification and economies of scope
   - increasing business interfaces and mass customization due to e-businesses
   - increasing business dynamics due to free trade and the shorter business cycles of products
   - increasing offshore relationships, larger distance between production and consumption, movement of production to far-reaching countries, as well as internationalization of labor forces due to globalization.

   As supply chains have grown in complexity, their- measurement, control, management, governance, development, and sustainable development have become consequently complex (Nilsson, 2005; Abbasi, 2008).

3. A third challenge consists of the socio-political interests – involving multiple external factors – that influence the sustainability of supply chains. This happens, for example, when the socio-political problems of energy suppliers jeopardize base industries, when economic problems influence exports, and when humanitarian crises make complex flows of goods as well as resources insecure.

4. Finally, the fourth challenge involves the conflicts of a paradoxical character related to the sustainable development of supply chains.
   - One example is decoupling economic growth from the increase in goods mobility and their environmental damage/degradation. Traditionally, the mobility of goods co-increases with the GNP. Another example is the paradoxes of simultaneous social growth and environmental damage. For example, shifting the upstream parts of supply chains to developing/emerging countries may accelerate their social and economic growth while at the same time deteriorate the natural environment due to longer transport distances among the supply chains stakeholders.
   - Another example is globalization as it may make acceptance of sustainability/ environmental laws and measurements of emissions more difficult. Social development by the construction of new infrastructures may increase mobility as well as energy consumption and global greenhouse gas (GHG) emissions by incautiously encouraging the usage of movable resources like motor vehicles.
   - A third example is the paradoxical consequences of production of carbon neutral fuels. For example, extracting biofuels from biomass may lead to higher income for rural communities, increase food output per hectare (productivity), and industrialize agriculture and forestry, while at the same time increasing land price, food prices, and hunger (Azar, 2005) or deteriorating the cultural carrying capacity (Hardin, 1991). Urbanization and industrialization may also strain the availability of biomass sources especially in developing countries (International Energy Agency, 2002).

1.2 A 2050 perspective

Sustainable development is one of the greatest global challenges facing human beings in the 21st century. At the least, alternative renewable sources of energy for fossil fuels without damaging side effects (chapter 5) have to be found; GHG emissions from industrial and man-

made activities – which have led to global warming and climate change – have to be decreased to *zero*; unemployment, poverty, and hunger need to be decreased while populations grow. Doing all these things together will be tremendously difficult but definitely necessary.

What is essential is to create a global sustainability culture in which all individuals, industries, businesses, organizations, and nations start primary steps towards tackling the challenges. Creating such a culture calls for long-term perspectives as, for example, it takes several decades to increase awareness and change the stakeholders' behavior.
In order to tackle sustainability related problems, several targets for 2050 have been set. Such long-term targets are essential as for examples it takes several years to construct/ reconstruct/ equip the infrastructures, redesign supply chains, redefine business models, develop radically and incrementally innovative clean technologies, identify challenges, design innovative strategies, and adapt to new legislation/regulations/laws/policies.

The next section presents a brief overview of some global, European, and national targets for reduction of CO_2 emissions.

Global targets

Logistics and transport activities are some of the main sources of emissions of greenhouse gases (GHG), mostly CO_2. Over the past decade, transport GHG emissions have increased at a faster rate than any other energy using sector (IPCC, 2007) and still represents the fastest-growing in the future (Browne, 2005). Freight transport has grown even more rapidly than passenger transport and is expected to continue to do so. It is estimated that freight transport accounts for roughly 8% of energy-related CO_2 emissions worldwide (McKinnon et al., 2010, p. 4). Globally, freight transport is expected to grow from approximately 15 trillion ton-kilometers in 2000 to around 45 trillion ton- kilometers in 2050 (World Business Council for Sustainable Development, 2004).

In a recent investigation, NASA (National Aeronautics and Space Administration) in the USA has shown that the mean temperature for land and ocean has increased more than $1^{o}C$ since the mid-20th century. With the current amount of root causes of global warming, it is forecasted that the mean temperature for land and ocean will increase more than $4^{o}C$ until the end of the 21th century (knowledge.allianz.com). Such increase will reduce crops yields, affect water resources, melt the ice sheet tremendously, raise sea levels, and alter marine ecosystems (metoffice.gov.uk). The Intergovernmental Panel on Climate Change (IPCC, 2007) concludes that most of the observed temperature increase is caused by increasing concentrations of greenhouse gases from human activity such as fossil fuel burning and deforestation. According to the Kyoto Protocol, greenhouse gases are natural (carbon dioxide, nitrous oxide, and methane) and industrial (perfluorocarbons, hydrofluorocarbons, and sulphur hexafluoride). Carbon dioxide accounts for by far the largest proportion (approximately 85%) of GHGs in the atmosphere, which is why there is so much attention focused on this particular gas (McKinnon et al., 2010). On the basis of current climate modeling, it is estimated that global greenhouse gas emissions will have to be reduced from 48 billion tons of CO_2 in 2007 to 24-28 billion tons in 2050 to keep the increase in average temperature within $2^{o}C$ (McKinnon, 2010).

European targets

In the European Union (EU), the demand for freight transport is expected to grow on average by 2.7% per year. The logistics sector in the EU still depends on oil and oil products for 96%

of its energy needs (EU, 2011). In this regard, the EU (including Sweden) has set goals to limit climate change below 2°C by drastically reducing GHG emissions – from all sectors of the economy – by 80-90% below the 1990 levels by 2050. It is also estimated that a reduction of at least 60% of GHGs by 2050 with respect to 1990 is required from the logistics sector. The EU (2011, p.9) also has the goal to *"halve the use of 'conventionally-fuelled' cars in urban transport by 2030; phase them out in cities by 2050; and achieve essentially CO_2-free city logistics in major urban centers by 2030."*

National targets

Forty percent of the CO_2 emissions in Sweden are from the transport sector (Energimyndigheten, 2010). Depending on where the systems borders are set, freight (goods) transport accounts for between 25% (just domestic transport) and 40% (both domestic and overseas transport) of CO_2 emissions (Energimyndigheten, 2010). As a result, 10-16% of CO_2 emissions in Sweden are due to freight transport. National freight transport is increasing in line with growth of the GDP and it is expected to double by 2050 (LETS-rapport, 2011). Sweden, as a member of the EU, is following the EU targets in reduction of GHG emissions.

Transition towards targets

By setting the targets for 2050, supply chains activities need to be transitioned towards the 2050 targets.

Transition can be defined as the "*continuous process of change where the structural character of a society (or a complex sub-system of society) transforms"* (Rotmans *et al.*, 2001, p.16). Rotmans and Loorbach (2009, p. 185) add that "*transition is a radical, structural change of a societal (sub) system that is the result of a coevolution of economic, cultural, technological, ecological, and institutional developments at different scale levels*".

The transition of supply chains towards the long-term (2050) targets is complex as it includes socio-technical changes with different time scales and governed by the decision making of a variety of actors. Furthermore, the transition path is and will continue to be different for different types of supply chains as they may be in different stage of development and influenced by different- types of social structure, natural resources, geographic location, and technical knowledge (Meza and Dijkema, 2009).

This transition calls for designing new strategies and continuously identifying and tackling the challenges that might hinder the operationalization of such strategies (Figure 1.1).

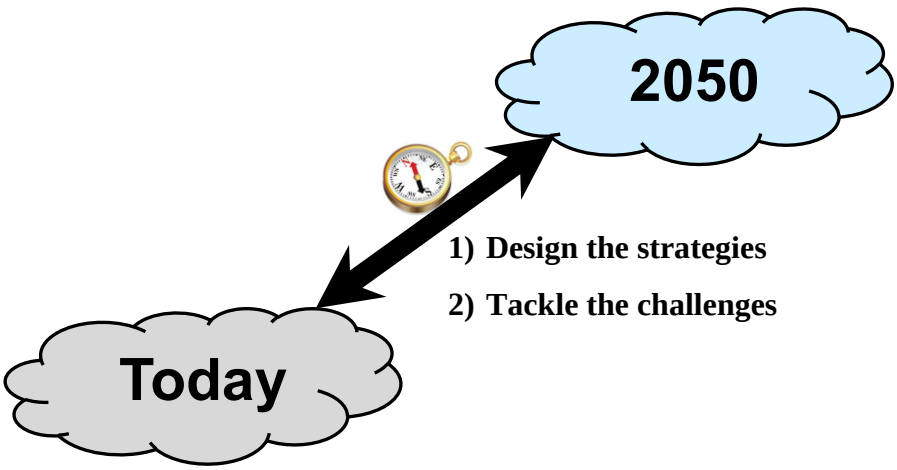

Figure 1.1 – Transition towards 2050 targets

This thesis argues that to understand and deal with the multidisciplinary and dynamic characteristics of transitions of supply chains activities, a complexity theory perspective would be beneficial. To better understand complexity theory, including processes of changes in supply chains, and explain different views on future states of supply chains, the concepts of teleology may be beneficial (Nilsson, 2005; Svensson, 2010).

"*The aim of teleology is to explain phenomena by the purpose they serve rather than by postulated causes*" (Oxford Dictionary). Stacey et al. (2000, pp. 14-15) refer to teleology as discussion about two things: *the kind of movement into the future that is being assumed* and the *reason for the movement into the future*. In regards to the first, a key distinction will be whether the movement towards the future is assumed to be toward a known state or an unknown state. In regards to the second, a key distinction will be whether it is assumed that a phenomenon moves towards the future in order to realize some optimal arrangement, a chosen goal, a mature form of itself, or continuity and transformation of its identity.

Stacey et al. (2000) suggest five notions of teleology that relate to the above discussion in different ways. These are Secular Natural Law Teleology, Rationalist Teleology, Formative Teleology, Transformative Teleology, and Adaptionist Teleology. Nilsson (2005) uses the notion of teleology in logistics and concludes that three of these are applicable to the context of logistics and supply chains management (SCM), namely rationalist, formative and transformative. Table 1.1, taken from Stacey et al. (2000, p. 52-54), summarizes three of the five different teleological notions.

The transformative teleology is the most prominent in modern complexity theory (Nilsson, 2005) while the other teleological stands can be found in some of its applications (Stacey et al., 2000). Since most environmental research is carried out in natural science and the majority of logistics and SCM research is based on positivism and reductionist reasoning (Svensson 2010), rationalist and formative teleology are predominant.

Setting optimally agreed long-term targets makes the future of supply chains and their agents barely recognizable – they have to become sustainable and develop sustainably by fulfilling the targets – but the strategies and challenges are subject to change and self-organization. The new strategies and challenges are influenced by the previous ones; they might be repetition of the past but with the potential for transformation.

Transformative teleology is well matched with the reality of supply chains when both freedom and conflicting constraints and paradoxes arise in the spontaneity and diversity of micro interactions (i.e. interactions among supply chains agents). As Nilsson (2005, p. 46) states: *"In these paradoxical change processes cooperation and competition, conflict and agreement, control and the inability of it, order and disorder, etc., are present simultaneously and are needed for future development"*. Understanding- complexity of supply chains, interactions among their agents, and creativity as well as novel changes inside them require this perspective of transformative teleology.

The pattern of current trends, themes and challenges need to be identified in the process of creating new strategies that matter for a sustainable society and the planet. Current trends and themes will influence the absorptive capacity (Fabrizio, 2009; Todorova and Durisin, 2007; Gao et al., 2008) of organizations and governments as radical suggestions might hinder instead of help the changes needed to reach the targets. In addition, the innovative strategies can be better designed by learning from the past ones (as stated in contingency theory).

Achieving the global, EU, and national targets appear to be tremendously challenging. It is obvious that with current business-as-usual approaches, the goals cannot be reached (EU, 2011, p.4-5). Instead new strategies with innovative solutions are required. Breaking the current approaches, ways of thinking, and patterns of behavior is fairly complex, costly, and time-consuming. Although innovation can be radical, adaptation of new technologies as well as change of behavior are just incremental (Rogers, 2003). In order to transform supply chains activities towards 2050 targets, the pattern of challenges need to be identified and classified and the challenges' influence on sustainability assessed. Finally, the challenges need to be tackled and continually reassessed.

	Rationalist Teleology	**Formative Teleology**	**Transformative Teleology**
Movement toward a future that is:	A goal chosen by reasoning autonomous humans	A mature form implied at the start of movement or in the movement. Implies a final state that can be known in advance	Under perpetual construction by the movement itself. No mature or final state, only perpetual iteration of identity and difference, continuity and transformation, the known and the unknown, at the same time. The future is unknown but yet recognizable: the known-unknown
Movement for the sake of/in order to:	Realize chosen goals	Reveal, realize or sustain a mature or final form of identity, of self. This is actualization of form or self that is already there in some sense	Expressing continuity and transformation of individual and collective identity and difference at the same time. This is the creation of the novel, variations that have never been there before
The process of movement or construction, that is, the cause is:	Rational process of human reason, within ethical universals, that is, human values. Cause is human motivation	Process of unfolding a whole already enfolded in the nature, principles or rules of interaction. A macro process of iteration, that is, formative cause	Processes of micro interactions in the living present forming and being formed by themselves. The iterative process sustains continuity with potential transformation at the same time. Variation arises in micro diversity of interaction, transformative cause
Meaning:	Lies in the future goals	Lies in the past enfolded form and/or unfolded future	Arises in the present, as does choice and intention
Kind of self-organization implied is:	None	Repetitive unfolding or macro pattern already enfolded in micro interaction	Diverse micro interaction of a paradoxical kind that sustains identity and potentially transforms it
Nature and origin of variation/change:	Designed change through rational exercise of human freedom to get it right in terms of universals	Shift from one given form to another due to sensitivity to context. Stages of development	Gradual or abrupt changes in identity or no change, depending on the spontaneity and diversity of micro interactions
Origin of freedom and nature of constrains:	Human freedom finds concrete expression on the basis of reason and ethical universals	No intrinsic freedom, constrained by given forms	Both freedom and constraint arise in spontaneity and diversity of micro interactions; conflicting constraints

Table 1.1 – Comparison of the frameworks for thinking about causality (taken from Stacey et al., 2000, p. 52-54)

1.3 Research purpose and questions

The purpose of this research was to explore and classify themes and challenges in developing sustainable supply chain activities in general, and freight transport and urban distribution in particular.

To achieve this purpose, it was first found necessary to take a holistic view of the pattern of currently discussed themes and challenges reflected in the literature. With a holistic view, insights could be gained of how different actors in the chain view sustainability, avoid designing sub-optimal strategies, and suggest close-to-reality solutions for tackling the challenges. The insights gained encouraged studies of themes and challenges in the context of logistical flows of materials and resources in supply chains. Such flows are influenced by supply chains design and operations and call for more investigation with a sustainability lens. In this regard, the purpose was narrowed to freight- transport and urban distribution activities of supply chains, which led to the following three research questions (RQ).

RQ1. What are the themes and challenges in making supply chains sustainable?

In the process of research, it became clear that little attention has been paid to challenges and barriers in supply chains' management and sustainable development (Richey et al., 2010). The existing perspectives, solutions and strategies that lead to sustainability are vague (van Hoek, 1999), especially those that emphasize the holistic perspective of supply chains or industries.

RQ2. What are the themes and challenges in making freight transport sustainable?

"*Traditional supply chain management focuses primarily on market and manufacturing issues, and transport has typically been considered as a rather marginal activity*" (McKinnon et al., 2010, p.119). However, the majority of negative (environmental) impacts of logistical activities emanate from freight transport (Wu and Dunn, 1995). Freight transport leads to atmospheric pollution (Global [GHG emissions], regional [like acid rain and photochemical smog], local [health and air quality]), noise pollution, accidents (McKinnon et al., 2010), injuries, congestion, visual intrusion, vibration, land-take, and more. Over the past decade, transport GHG emissions have increased at a faster rate than any other energy using sector (IPCC, 2007) and still represent the fastest-growing in the future (Browne, 2005). Freight transport has grown even more rapidly than passenger transport and is expected to continue to do so (World Business Council for Sustainable Development, 2004).

During the research process, it was determined that themes and challenges be explored from the logistics service providers' (LSPs) perspective. This was because of the increase in outsourcing of logistical/supply chain services to LSPs (Wolf and Seuring, 2010; Stefansson, 2006; McKinnon et al., 2010, p.116) as well as less research on sustainability promotion and polices (Wigan and Southworth, 2004; Himanen et al., 2004; Lieb and Lieb, 2010). According to Wolf and Seuring (2010), the transport activities of LSPs are the single largest source of environmental hazards and CO_2 emissions in the logistics industry.

RQ3. What are the themes and challenges in making urban freight distribution sustainable?

As a result of rapid expansion of the planet's urban population, urban areas continue to grow at a faster rate than any other land-use type. In Europe, approximately 80 percent of the citizens live in urban environment (McKinnon et al., 2010). On the same continent, 85% of the GDP (Gross Domestic Product) is generated in cities (EU, 2009). Freight distribution in urban environments has a unique array of challenges as a multidisciplinary field (Dablanc,

2007). Until relatively recently, little attention has been paid to urban freight by researchers and policy makers (Álvarez and de la Calle, 2011). The scenario becomes even worse when it comes to awareness of-, and attention to-, sustainable urban freight distribution as "*the problems experienced by those performing freight transport and logistics operations in urban areas are far less well understood*" (McKinnon et al., 2010, p.286).

1.4 Research scope and demarcations

Three research studies (RS) were designed and carried out to answer the three research questions. The studies focused on environmental aspects of sustainability, but due to the integrated nature of sustainable development, economic and social aspects were also taken into account. Phrases such as "environmentally sustainable/friendly/sound/preferable/ responsible", "eco", and "green" were considered synonymous.
The scope of the first research study (RS1) was a holistic view on all supply chain activities (Figure 1.4.a).

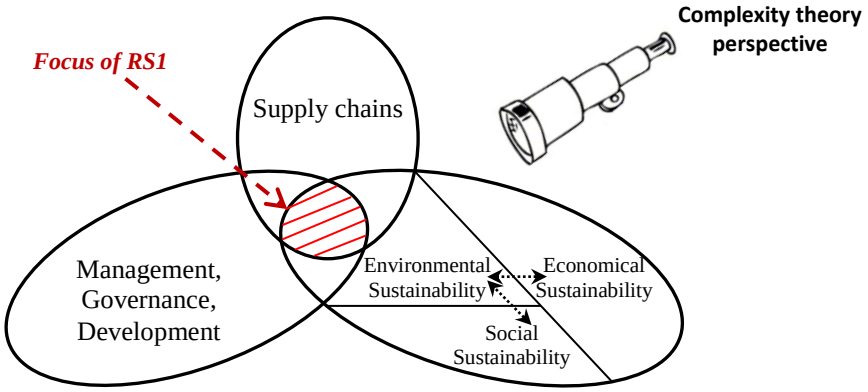

Figure 1.4.a – Focus and demarcation of the research study 1

The second study (RS2) was limited to freight transport and the third study (RS3) to urban freight distribution activities of supply chains. Although it is difficult to define clear borders between supply chain activities, Figure 1.4.b depicts the standpoint of the author to the main activities (of supply chains) that are related to procurement, production and manufacturing, packaging and handling, marketing, consumption, retailing, transport, and distribution.

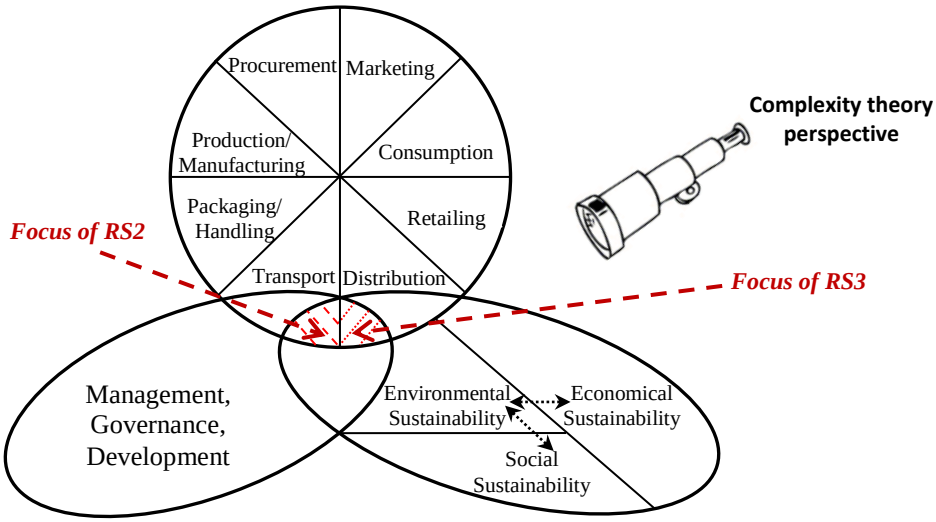

Figure 1.4.b – Focus and demarcation of the research studies 2 and 3

The whole research process (refer to chapter 2) was based on a complexity theory perspective. This led to further discussion about management, governance and development of sustainable supply chains activities reflected in chapter 5.

1.5 Research projects

This research was made feasible through two research projects: LETS 2050 and Øresund EcoMobility. The following summaries of these projects are taken from their websites. The contributions of the author are also mentioned.

LETS 2050

LETS 2050 (Governing transitions towards **L**ow-Carbon **E**nergy and **T**ransport **S**ystems for 2050) is an ongoing project financed by the Swedish Governmental Agency for Innovation Systems (Vinnova), Swedish Transport Administration (Trafikverket), Swedish Environmental Protection Agency (Naturvårdsverket), and Swedish Energy Agency (Energimyndigheten).

> The core mission of the LETS 2050 research program is to identify, explore, and suggest ways that Sweden can implement low-carbon energy and transport systems for 2050, in order to reach the ambitious climate policy objectives suggested by the 2°C target. (...) The research within the LETS program is based on the presumption that it is technically possible and economically doable to make the transition to a low carbon society, but what needs to be done is to find the paths to get there. Hence, the overarching research question is: *What societal transitions are implied by low-carbon futures and how can these transitions be governed and implemented to meet challenging climate policy objectives?*
>
> Low-carbon futures necessitate shifts to carbon-free energy carriers produced in low-carbon conversion processes and changes in consumption behavior. When accommodating such shifts, existing political and administrative regimes are challenged by the need for climate policy integration across policy domains, dynamic consistency, new planning tools and processes, ceding power to the appropriate level, etc. The outputs from LETS range from high-level research based policy advice to tools and guidelines for the "street level" implementing agencies and other administrative bodies. The research team brings together key disciplines from social sciences, economics and engineering (i.e. energy and transport system studies).
>
> (LETS 2050 website: http://www.lth.se/lets2050/english/about_lets/, accessed April 11, 2012.)

LETS 2050 includes six research areas or work packages:

> ***WP0: Future policy scenarios and alternative pathways***
> WP0 studies alternative technological and policy scenarios and asks: What kind of transformations, in terms of technological and behavioral change, are required for LETS to meet challenging climate policy objectives? What are the political, economic and social challenges associated with such transformations? What alternative pathways towards LETS are possible under various scenarios?
>
> ***WP1: Governance: Developing institutions and policy***

> WP1 considers implications for policy and institutional change and asks: What type of governance, in terms of institutions and policy, are needed to enable the transition towards LETS? And how can such institutions handle a set of governance dilemmas such as legitimacy, accountability, dynamic consistency, effectiveness and efficiency related to climate policy?
>
> ***WP2: Urban and regional planning and infrastructure***
> WP2 studies urban and regional planning and changes in infrastructure as means for reducing greenhouse gases and asks: What tools, instruments and recommendations are necessary to (re)organize the built environment and transport system in order to enable and support the transition towards LETS?
>
> ***WP3: Markets, industry and policy for bioenergy***
> WP3 focuses on fossil fuel substitution using biomass and asks: What are the market and resource implications of high carbon prices? What are the sustainability challenges, commercial opportunities and policy options involved in governing the transition to increased use of bioenergy?
>
> ***WP4: Citizen-consumers and voluntary instruments***
> WP4 looks at implications of "soft" policy and voluntary instruments, as complements to regulation and market based instruments, and asks: What type of voluntary policy and planning instruments will contribute to behavioral change among citizen-consumers consistent with the transition towards LETS?
>
> ***WP5: Logistics and goods transport***
> WP5 focuses on the interplay between freight transport and logistics and asks: What are the challenges, opportunities and incentives of companies and the society regarding sustainable freight transport and logistics configurations in order to enable a change towards LETS? What types of instruments and policies have sufficient effect, relevance and feasibility to make freight transport sustainable?"
>
> (LETS 2050 website: http://www.lth.se/lets2050/english/research_areas/, accessed April 11, 2012.)

LETS 2050 has strong interactive research among all work packages. I am involved in WP5 (Logistics and goods transport). My main task is the study of the challenges to sustainable development of logistics and goods transport. These may relate to both current and future socio-technical as well as geo-political challenges. I have also started studying the governance of transition of logistics to sustainability, especially the challenges that might emerge while this transition is governed.

Øresund EcoMobility

Øresund EcoMobility is co-funded by the European Union and Interreg IVA.

> The Øresund EcoMobility project is a Swedish-Danish cross-border initiative that unites universities, companies and authorities in an effort to increase competence within climate friendly transport of both goods and people. The project builds on a unique network of over 40 experts in areas such as cleantech, environmental science, infrastructure, city and transport planning, logistics and supply chain management. These experts jointly constitute the Øresund EcoMobility Knowledge

& Innovation Centre which gather, create and spread knowledge about climate friendly mobility. (Øresund EcoMobility Fact Sheet: http://www.oresundecomobility.org/about-us, accessed April 11, 2012.)

The project consists of three networks (Green Logistics Hub, City Transport and Logistics, and Biofuels and Energy Systems) and is built on three stages:

1. Cross-science Triple-Helix *Thematic Knowledge Exchange Networks;* which gather knowledge on climate friendly transportation of goods and people.
2. *Øresund EcoMobility Knowledge & Innovation Centre*; which carries out knowledge dissemination, innovation and competence building.
3. *Øresund Competence Building and Knowledge Sharing Activities;* such as publications, websites, workshops, conferences and courses for professionals, university students, etc. (Øresund EcoMobility Fact Sheet: http://www.oresundecomobility.org/about-us, accessed April 11, 2012.)

The Øresund EcoMobility project is in its final stages. My main task in this project has been the study of themes as well as challenges in developing sustainable city logistics.

1.6 Readers' guidance

The main target groups of this thesis are researchers and students in the disciplines of supply chains, logistics, and sustainability studies. Study of this thesis is also highly recommended for managers and policy makers as it can be beneficial when they approach sustainable supply chains- management, governance, development, and challenges.

Chapter 2 describes the research process; chapter 3, the theoretical frame of reference and definitions; chapter 4, the results of the research studies; chapter 5, complementary discussions; and chapter 6, closing remarks. Researchers and students are recommended to read all the chapters sequentially. Other readers, including managers and policy makers, are recommended to read (at least) chapters 1, 5, and 6 sequentially.

2. CRAFT OF RESEARCH

"The whole of science is nothing more than a refinement of everyday thinking."

Albert Einstein

This chapter provides an overview of the research journey (research process) from definition/development of research questions to communication of the research answers and results.

2.1 Scientific research

The ultimate aim of this research was to produce knowledge in a scientific process by finding valid and reliable answers to the research questions as well as further discussion. This process calls for a systematic collection, analysis, and communication of data (Figure 2.1). The scientific process in this research was started by clarifying the ontological, epistemological, and teleological standpoints. These are important as they later influence the data that will be collected; how they will be collected; how they will be analyzed; theories and assumptions that will be considered; and types of perspectives, views and paradigms that are required. After designing the research studies, the right data from the right sources by the right methods were rightly collected, analyzed, and synthesized. Finally, the results of the research (knowledge) were communicated to several target groups through a number of channels.

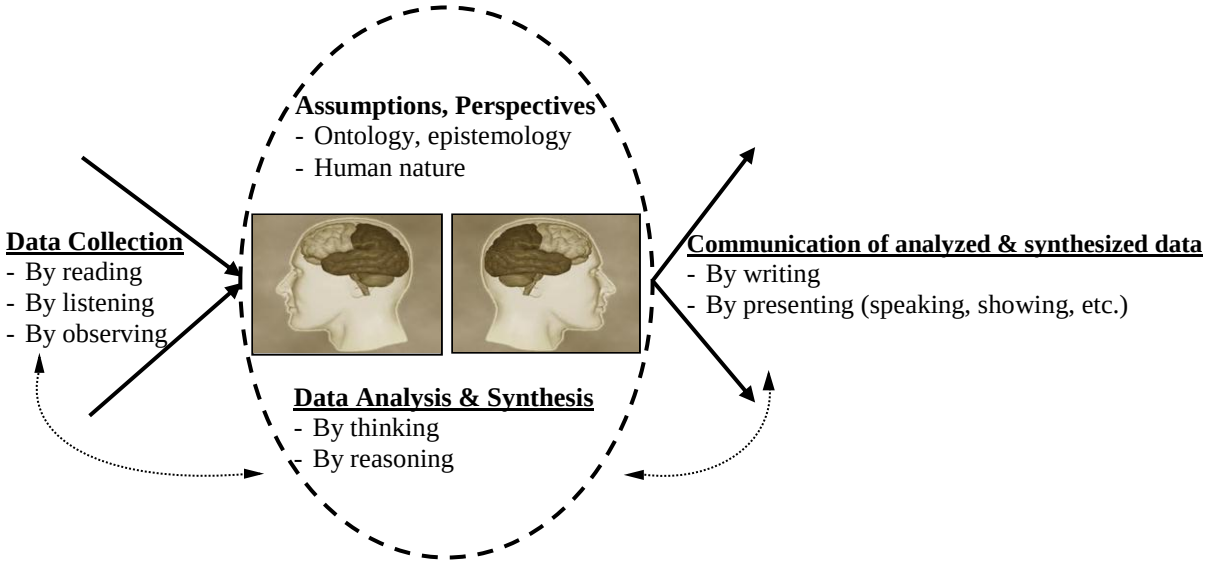

Figure 2.1 – Scientific process in this research

Figure 2.2 presents an overview of the main stages of the research process, in this research, namely: defining research questions, defining scientific assumptions, defining research strategy, design of the research, collection of data, analysis and synthesis of data, and communication of results/answering the research questions.

As shown in Figure 2.2, most of the stages of the research process were simultaneously carried out while developing during the research journey. However, defining research questions, strategies and the design of the studies were mainly in the initial stages of the

research process, communication of results in the final stages, and collection and analysis of data almost in parallel with other stages.

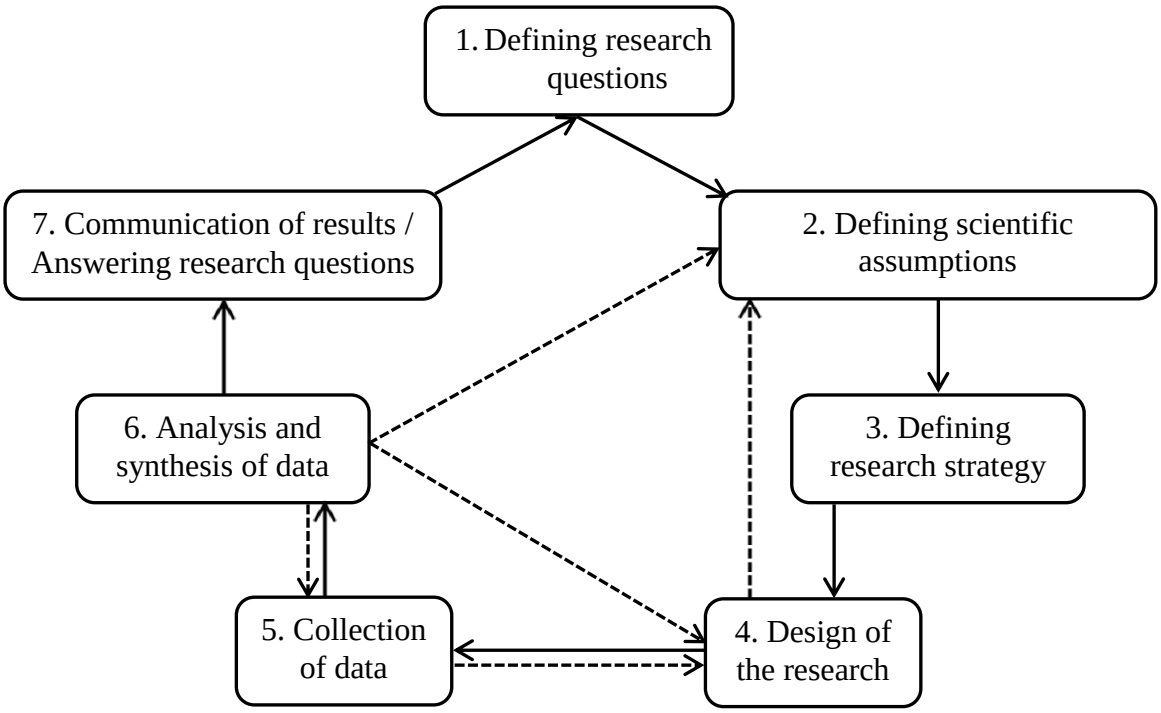

Figure 2.2 – An overview of research process in this research

In the following sections, the research process from defining to answering the research questions is explained. The criteria for judging quality (trustworthiness and authenticity) of the research are also discussed.

2.2 Defining research questions

The research purpose and questions were set by realizing the challenging nature of developing sustainable supply chains activities in industries. In addition, as mentioned in the first chapter, it was determined that little research has been done on sustainability challenges in the context of supply chains.

However, other factors had a direct or indirect influence on defining the three research questions such as the researcher(s)' interests and previous knowledge and experience; research projects' interests; feedback from other researchers, consultants, policy makers, and industries. The first research question was defined in the initial stages of the research journey while the others developed during the research process, especially when the results of the first research study showed the necessity of studying themes and challenges in the context of freight transport and distribution. Achieving a sustainable society, and in this specific case the aspects related to supply chain and transportation, was found to contribute to industry and to the planet as such.

2.3 Defining scientific assumptions

Scientific assumptions are related to my ontological, epistemological, and teleological standpoints as well as the perspectives that were with me all the time during the research process.

2.3.1. Ontological position

"*Ontology is a branch of metaphysics dealing with the nature of being*". (Oxford dictionaries) According to Bryman and Bell (2007), social ontology is concerned with the nature of social entities and the meanings of social phenomena where the central point of orientation is *objectivism (realism)* or *constructionism (constructivism or nominalism).*

My ontological standpoint in this research was mainly towards constructionism. In my opinion, supply chains are constructed by social actors. In fact, it is the supply chain agents and stakeholders that give meaning to its existence. Management, governance, and development of supply chains require an understanding of subjectivity and revisions in supply chains strategies and operations. Supply chains resources are also tied to revision, change and reconstruction in the short or long term. These resources are *tangible* (physical [static and movable], financial), *intangible* (brand, reputation, culture, technologies) and *human* (skills, motivations, capacities).

The sustainability of supply chains activities is also tied to subjectivity. Sustainable development of supply chains depends on the eyes of its beholder. Its social activities, for example, may be sustainable for social actors of a specific society (like a country) while unsustainable for actors of another. Sustainable development of supply chains may also vary at different time periods.

2.3.2 Epistemological position

Epistemology is the philosophy of knowledge and involves long-standing debates about what knowledge is and how it is obtained (Kvale and Brinkmann, 2009). The central point of orientation in epistemology is *positivism* or *interpretivism (anti-positivism or relativism)* (Bryman and Bell, 2007).

My epistemological stance in this research was mainly anti-positivistic with some elements of positivistic epistemology. In the anti-positivistic stance, I studied themes and challenges in relation to sustainability, including social, aspects of the actions of supply chains actors. Studying supply chains from this standpoint is better matched with the subjectivity that is intrinsic in management, governance, and the development of supply chains. As Nilsson (2005, p. 35) states: "*Processes and phenomena, where human beings are involved, are not simply a sequence of mechanical devices which can be assumed to work along positivistic beliefs, are instead a complex network of living, innovative, creative and evolving creatures which react and adapt dynamically to their perceived environment, and try proactively to create what they themselves, or collectively with others, find to be beneficial to their own interests."* In addition to this subjectivity, the knowledge generated about themes and challenges became completely anti-positivistic because in the beginning of the research I did not have a clue about what all these emerged themes and challenges would be.

From a complexity theory perspective, both positivistic and anti-positivistic epistemological positions are present in the knowledge generated about management, governance, and development of sustainable supply chains activities (reflected in chapter 5). The knowledge in chapter 5 was generated (anti-positivism) from already known characteristics and themes of the complexity theory perspective and science of complexity (positivism).

2.3.3 Teleological position

My teleological assumptions of supply chains are better matched with transformative teleology where the kind of movement into future is both known and unknown while the

reason for the movement is both continuity (in this research, sustainability) and transformation of identity (in this research, developing sustainably until *at least* the 2050 targets are met).

2.3.4 Moving beyond a systems perspective to a complexity theory perspective

An underlying premise in most of the theories and practice of logistics and supply chains management is a systems perspective necessitating systematic and holistic thinking. Systematic thinking necessitates a holistic view of systems (Senge, 1990) by analyzing both characteristics of components of the systems and synthesizing characteristics of interdependencies/interconnections of the components (Patton, 2002, p. 120). Supply chains components are so interdependent that changes in one component lead to changes in all components and the entire supply chains. In other words, the characteristics/ properties/ behaviors of the supply chains are different from those of each component.

A complexity theory perspective goes one step further than a systems perspective and reflects the openness of the systems and their boundaries; why and how changes in the systems and their surrounding environments occur and co-influence each other; and considers the nonlinear dynamics of systems' interconnections and existing paradoxes. There are a growing number of researchers applying complexity theories and approaches with the conclusion that they are beneficial in creating increased understanding of the complex and challenging issues companies are confronted with today and of the complex phenomena that supply chains or networks represent. However, for the future development of the logistics and supply chain management discipline, reflections of ontological, epistemological, and teleological assumptions ought to be made. This is because logistics and supply chain management research has a history of being strongly influenced by positivism (Mentzer and Kahn, 1995), that is to say, influenced by assumptions such as rationality, stability, objectivity, linearity, determinism, value-freeness, designability, and controllability.

Nilsson (2005) challenges the positivist assumption underlying the systems approach to logistics and supply chain management. Some exemplary assumptions are rational behavior of people; simplification of the systems to make them efficient and optimized; an objective context-independent reality where uncertainties are neglected; determinism; deliberate design; unbiased and noise-free information flows. However, since positivist and postpositivist assumptions are predominant in general management when adopting system approaches (Stacey et al., 2000) and in the tradition of positivism in logistics and supply chain management, the influence of positivism when adopting a systems approach to logistics and supply chain management research might be prevalent. Nilsson (2003, 2005) concludes that the underlying assumptions of two branches of complexity theory namely, complex adaptive systems (CAS) and complexity thinking (CT) are more appropriate than systems approach (SA) for research of contemporary challenges of organizational complexity in logistics and supply chain management, such as the challenges of sustainability, innovation, collaboration, and sense making.

These two branches of complexity theory (CAS and CT) are discussed in more details in the chapter 3, Frame of Reference. It is from the perspectives of CAS and CT that management, governance, and the development of transition of supply chains activities towards the 2050 targets can be better studied. CAS and CT reflect the co-adaptive, co-evolutionary, nonlinear and paradoxical nature of the transformative transition of supply chains towards long-term (2050) sustainability targets.

2.4 Defining research strategy

By defining the research questions and scientific standpoints, the strategy for doing the research emerged. Research strategies can be considered as quantitative, qualitative, or mixed. According to Bryman and Bell (2007), *quantitative research* can be broadly described as entailing the collection of numerical data and as exhibiting a view of the relationship between theory and research as deductive, a predilection for a natural science approach (and of positivism in particular), and as having an objectivist conception of social reality. On the other hand, *qualitative research* is a research strategy that usually emphasizes words rather than quantification in the collection and analysis of data. Qualitative researchers have mostly an inductive view of the relationship between theory and research, whereby the former is generated out of the latter, an epistemological position described as interpretivism and an ontological position described as constructionism.

The strategy of this research was mainly qualitative due to its constructionist ontological assumptions, interpretivist epistemological standpoints, and because it was properly fitted to management studies (Gummesson, 2000). The reasoning logic (Hugh and Gauch, 2003) or approach (Spens and Kovács, 2006; Kovács and Spens, 2005) behind the research was mainly inductive, which has appeared in relatively few existing studies in the logistics literature (Carter and Rogers, 2008). The results of a content analysis of research approaches in logistics (Kovács and Spens, 2005) also show the dominance of deductive positivism. The inductive approach in this research meant letting the themes, challenges, and further propositions emerge out of the study of supply chains as well as freight transport and distribution. Such an inductive approach is better matched to qualitative research strategy.

However, the characteristic of the discussion about management, governance, and development of sustainable supply chains activities (reflected in chapter 5) out of the themes and theoretical framework of the science of complexity became more deductive. In this regard, the approach was abductive (Spens and Kovács, 2006; Kovács and Spens, 2005) rather than purely inductive.

2.5 Design of the research

Research design presents a structure that guides the execution of research method(s) and the analysis of the subsequent data. Bryman and Bell (2007) outline five prominent research designs: experimental, cross-sectional, longitudinal, case study, and comparative.
Although due to trade-offs there is not a perfect research design (Patton, 2002, p. 223), this research has a dominant cross-sectional design. "*A cross-sectional design entails the collection of data on more than one case (usually quite a lot more than one) and at a single point in time in order to collect a body of data in connection with two or more variables (usually many more than two), which are then examined to detect patterns of association*" (Bryman and Bell, 2007, p. 55).

As shown in Figure 2.3, each research study (RS) was designed in order to find trustworthy and authentic (refer to section 2.9) answers to its corresponding research question. It was determined that the pattern of themes and challenges in making supply chains, freight transport, and urban freight distribution sustainable inductively emerged out of the collected data. As explained in the next section, data were collected from different sources at a single point in time. Themes and challenges were generalized from the identified patterns of discussion in selected samples of literature and interviewees.

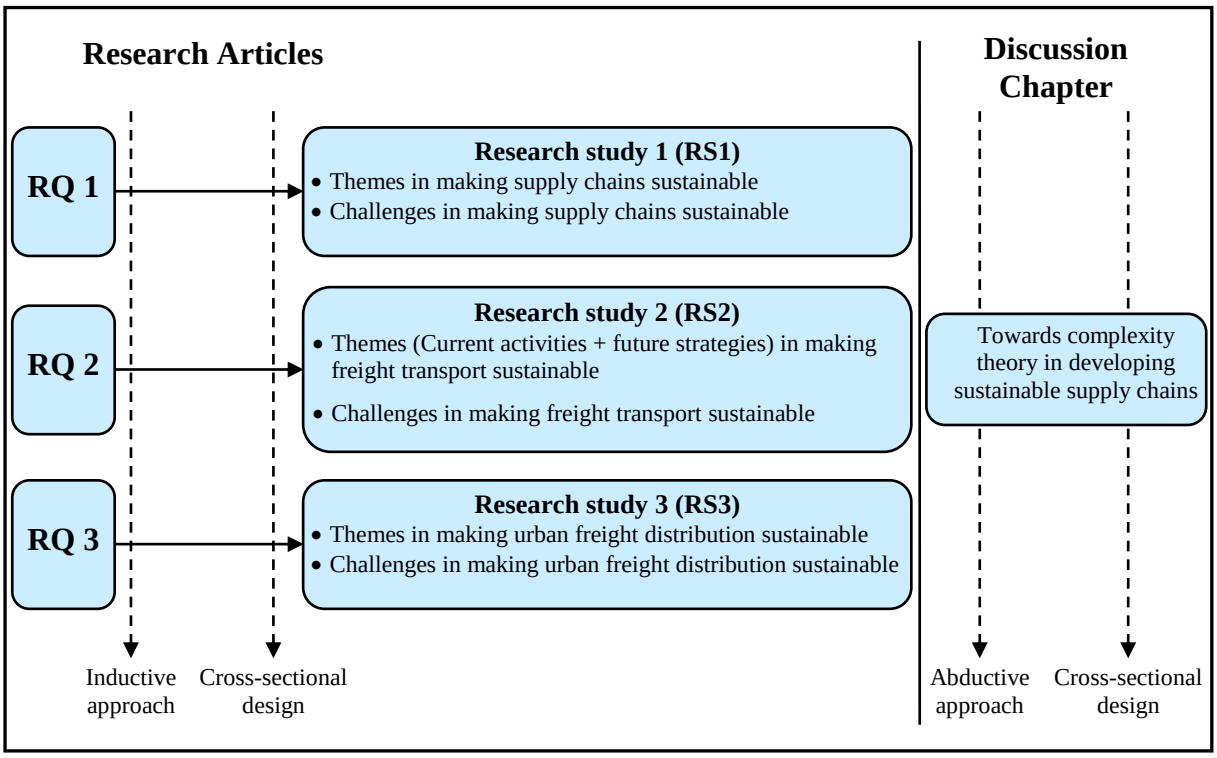

Figure 2.3 – Design of the research studies

2.6 Data collection

During and after the design of each research study (RS), data were collected by triangulation (Patton, 2002, p. 247, 555) of different research methods. As a result, data were collected from a variety of sources, by different researchers on some occasions, and by different methods. Triangulation is also identified in the variety of theories and perspectives considered in this research. However, research design, data collection, and data analysis were mixed (Patton, 2002, p. 248) and overlapping as they were not completely sequentially carried out.

RS1 was treated theoretically while RS2 and RS3 were treated both theoretically and empirically. A summary of different research methods for the collection of data is presented in Table 2.1.

Method of data collection	Research Study	Description
Literature review	RS1 RS2 RS3	• Peer reviewed journal and conference articles • Books, licentiate and doctoral theses • Documents and reports from selected websites and media • Documents and reports of the research projects
Content analysis	RS1	• Content analysis of selected articles (unit of analysis) from selected journals
Interviews	RS2	• Qualitative semi-structured interviews with selected LSPs

Table 2.1 – Methods of data collection in this research

2.6.1 Literature review

Review of existing literature was the common method of data collection for all research studies in the whole the research process. The purpose of exploring the existing literature was to become familiar with what is already known about the research area; the main concepts, theories and themes of this area; and the significant controversies and unanswered research questions. According to Bryman and Bell (2007), a literature review can be categorized as *systematic* or *narrative*. The later one tends to be less focused and more wide-ranging in scope than the former. The second research study took advantage of the narrative literature review while the first and third studies were initiated by narrative literature reviews and continued with systematic ones (for more information, please refer to the appended papers).

The literature was from secondary sources and documents:

Peer reviewed journal and conference articles

To collect a reliable sample of articles, the online database at the Lund University Library in Sweden (Summon – previously named ELIN) was selected. It includes sources such as electronic journals, E-print archives, JSTOR, IEE/IEEE standards and proceedings, and the Proquest ABI database.

Books, licentiate and doctoral theses

Some hard copy or electronic books as well as licentiate and doctoral theses relevant to the purpose of the study were read during the data collection and analysis phases.

Documents and reports from selected websites

Relevant documents (public, organizational, and company documents as well as mass media outputs) from trustworthy reports, websites, and media were also read.

Documents and reports of the research projects

Almost all relevant publications, documents, and reports available on websites or intranets of the research projects were studied during the data collection phase.

However, some primary sources of literature – like theses, reports, and book chapters previously written by the author – were also considered during the collection of data.

2.6.2 Content analysis

The first research study (RS1) also took advantage of content analysis for both data collection and analysis. Content analysis is a set of research tools for the scientific study of written communications with the objective of determining key ideas and themes contained within them (Cullinane and Toy, 2000).

Content analysis can be both qualitative and quantitative, where the latter seeks *"to quantify content in terms of predetermined categories and in a systematic and replicable manner"* (Bryman and Bell, 2007, p. 302). Qualitative content analysis can satisfy the inductive assumptions of qualitative researchers. Qualitative content analysis comprises an exploration of underlying themes in the materials being analyzed. The aim is to be systematic and analytical but not rigid. With qualitative content analysis there is much more movement back and forth between conceptualization, data collection, analysis and interpretation than is the case with quantitative content analysis (Bryman and Bell, 2007). The process of content analysis in RS1 was mainly qualitative, as the area of investigation was complex and based on a variety of examples, cases, methods, perspectives, etc. In what follows, several steps of content analysis are briefly explained.

Selection of a sample
In order to answer the first research question, a relevant and valid sample of literature had to be systematically selected. The sampling method in RS1 was based on convenience and non-probability. The selection of convenience sampling was used not only to obtain a reliable and relevant base of journals and articles but also due to their availability and accessibility (other types of sampling are *snowball* and *quota*).

In the first step, the *Electronic Library Information Navigator@Lund* (*ELIN*) was selected as a database for journals. The research question called for sampling two types of journals: those related to supply chain management (type one) and those related to environmental sustainability (type two). In order to narrow the number of journals, relevant keywords were chosen. Type one journals were restricted to those that contained one or some of the following keywords: "Supply chain", "Logistic-", "Transport", and "Transportation". Selected keywords for type two journals were "Sustainability", "Sustainable", "Environment", "Environmental", and "Green".

The next step was the selection of a sample from the number of journals of both types. This selection was carried out through a ranking process. Two criteria were considered to rank the journals: *citations* and *impact factors*. Journals with the highest citation number were selected through the website *www.journal-ranking.com*, while those with the highest impact factor were chosen based on the website *www.isiwebofknowledge.com*. The result was that six type one journals and twelve type two journals were selected based on the highest number of citations and impact factors (see appended paper I).

Unit of analysis
The recording unit is the smallest body of text in which an example of one of the content categories appears. *Relevant article* was the unit of analysis in RS1. The reason for this selection was to analyze how relevant articles in the journals selected deal with environmentally sustainable/friendly/sound/preferable supply chains. Such articles were selected according to the following procedure:

A) Based on the initial literature review, concepts related to the research area were used to identify suitable articles in both types of journals. Articles selected from type one journals were organized and recorded in a database. They had to include one or more of the following words in the title, keyword, or abstract: "Sustainability", "Sustainable", "Environment", "Environmental", and "Green". For type two journals, "Supply chain", "Logistic- or Logistic*", and "Transport-" were the keywords chosen for the search. The sample included published articles dating from the first issue of each journal until the end of 2009.

B) The articles were analyzed and ranked by the authors working individually. Both authors were responsible for reading an abstract of each article and ranking its relevance to the research question by color coding it into the following: relevant (green), semi-relevant (yellow) or not relevant (red).

C) Finally, results of analyses by both authors were compared and further discussions were held to select the most relevant articles.

In total, the review resulted in 190 relevant articles out of the total sample of 3637 (5.2%). However, 2407 of the suitable articles were from *Environmental Science and Technology*.

Coding
There are two main elements to a content analysis coding scheme: designing a coding schedule and designing a coding manual. The *coding schedule* is a form into which all the data relating to an item being coded are entered. The *coding manual*, sometimes referred to as the *content analysis dictionary*, is a set of instructions to coders that specifies the categories used to classify the text. Categories need to be devised to provide the basis for classifying textual content (Cullinane and Toy, 2000).

The coding manual in RS1 was both deductive and inductive. In RS1, two categories were determined in advance: level of discussion in the supply chain, and treatment of sustainability. In the qualitative analysis of themes, the sub-categories were created inductively and were driven by the question of which themes and challenges had been put forward and how these had been discussed.

2.6.3 Interviews
Qualitative semi-structured interview was another method of data collection in the second research study (RS2). Semi-structured interview typically refers to a context in which the interviewer has a series of questions, often referred to as an interview guide, that are in the general form of an interview schedule but is able to vary the sequence of questions (Bryman and Bell, 2007).

The main reason to select this type of interview was to understand themes and challenges in making freight transport sustainable from the interviewee's (LSPs) perspective by an intersubjective social co-construction of knowledge among interviewers and interviewees. The interviewees were encouraged to describe their current activities, future strategies, and challenges in making freight transport sustainable precisely in the way that they experience and feel it. The interviewers exhibited openness to new relevant dimensions or discussions out of the interview guide (refer to the appendix). The interviews were neither strictly structured with standardized questions, nor entirely nondirective.

The interview study in RS2 was designed based on the seven stages of a qualitative interview investigation suggested by Kvale and Brinkman (2009): thematizing, designing, interviewing, transcribing, analyzing, verifying, and reporting.

Thematizing and designing
Based on earlier research and experience of sustainable development in the context of logistics and supply chain management together with a number of discussions and seminars with logistics managers, it was found that there are several challenges in making freight transport sustainable. Looking at supply chains, the main actors in freight transport are the logistics service providers (LSPs). Hence, it became natural to get a LSP perspective on the challenges of sustainable freight transport. To get a comprehensive and doable sample, the research focused on LSPs active in Scandinavia. A list of 30 LSP companies was initially set out. The list included both small and large LSPs. Then, as a combination of snowball sampling and earlier contacts at the LSP, we ended up with a list of interviewees. Each potential interviewee was first contacted by an e-mail, in which the purpose of the study, a description of the research area (sustainable freight transport) and an invitation to an interview were included. This was then followed up by a telephone call in which any extra information was given and dates set for the interview. In total twelve logistics and/or sustainability managers from nine LSP companies (DHL, Maersk, Schenker, Green Cargo, Bring, DSV, Transport ledet, SAS Cargo, and Lastbil centralen) were interviewed.

The majority of the interviewees had long experience (20 years or more) of sustainability as well as transport and logistics operations. Most of them had a top management position for the regional LSP offices for the Scandinavian market (if the LSP was part of an international organization) or in the management team (for those operating in one nation).

The data collection process ended when saturation was reached. After interview seven, we evaluated the process and started to feel that no more significant or new information was really gained for the purpose of our study. To ensure the research quality, two more were conducted, from which we then concluded that data saturation was reached. The sample size for this type of research is, according to McCracken et al. (1990), eight for homogeneous samples; Carter and Jennings (2002) suggest 12-20 for heterogeneous samples. In this case the companies and interviewees operate in the same geographical regions, working on similar issues. Hence, compared to more global studies or studies in different industries, the sample might be regarded as homogeneous.

Interviewing

The interviews were semi-structured, including both open-ended questions and a questionnaire at the end. The interviews lasted for about 90 minutes. An interview guide was developed for the open-ended questions divided into three major areas: current activities for sustainable development, future activities and trends for sustainable development (until 2050), and the challenges of sustainable development.

The discussions focused on these areas for LSPs specifically and for freight transport in general. Prior to each interview an in-depth study of each LSP's website was carried out and information about the company in general as well as about sustainability related activities, statements, reports, etc., were compiled. All relevant information was documented in the interview study database so it could be accessible in all phases of the analysis.

Transcribing

Every interview was taped and there after transcribed. If there were any possible misinterpretations or questions found during the transcriptions, follow up contact was made with the interviewee. Interviewees were asked to read the transcribed text and send the reviewed transcription to the authors. Each sound file as well as transcription was then placed in the interview study database.

2.7 Analysis and synthesis of data

Analysis was carried out both during and after data collection. Qualitative analysis transforms data into findings. Although there is not any formula or recipe for that transformation (Patton, 2002, p. 432), the analyses were guided by principles of content analysis, discourse analysis, analytic induction, and grounded theory (Table 2.2).

The first research study (RS1) applied content analysis to the interpretation of discussed themes and challenges in the units of analysis (selected articles). Principles of discourse analysis were the main tools for data analysis in the second research study (RS2). The principles were inspired by discourse psychological aspects (Winther and Phillips, 2000) as the standpoint was that current activities and future strategies of the interviewed logistics service providers construct the main parts of themes and challenges in making freight transport sustainable. However, an inductive interpretation of these themes and challenges moved the epistemological standpoints towards subjectivity.

Method of data analysis	Research Study	Description
Content analysis	RS1	• Interpretation of themes and challenges reflected in selected articles (unit of analysis) from selected journals
Discourse analysis	RS2	• Construction of themes and challenges in subject to the interviews with LSPs
Analytic induction	RS3	• Universal explanation of categories of themes and challenges
Grounded theory	RS1 RS2 RS3	• Towards development of hypotheses and further discussion after theoretical saturation of categories of themes and challenges

Table 2.2 – Methods of data analysis in this research

Analytic induction (Bryman and Bell, 2007; Patton, 2002) was the main strategy for data analysis in the third research study (RS3). The principle was to seek a universal explanation of categories of themes and challenges in making urban freight distribution sustainable by pursuing the collection of data until no cases that were inconsistent with the emergent categories were found.

All the discussed methods of data analysis in the research studies were inspired by tools of grounded theory. The analyzed data were then synthesized (aggregation and substantiation of knowledge), which led to the development of hypotheses in the research articles and further discussion in the discussion chapter.
The common tools of grounded theory in all research studies were sampling, coding, and saturation (taken from Bryman and Bell, 2007). Collection of data was continued until theoretical saturation was reached. This means that successive interviews/literature had both formed the basis for the creation of a category – after open and focused coding (Charmaz, 2006) – and confirmed its importance. There was no need to continue with data collection in relation to that category or cluster of categories, and themes and hypotheses were generated out of the categories that were established.

It is worth mentioning that "*code memos*" (Kvale and Brinkmann, 2009) were used during open and focused coding where the names of the different codes, who coded which parts of the material, the date when the coding was done, definitions of the codes used, and notes about the codes were recorded. The generation of codes was purely "*data driven*" rather than "*concept driven*". Concept-driven coding uses codes that have been developed in advance by the researcher, either by looking at some of the material or by consulting existing literature in the field. Data-driven coding means that the researcher starts out without codes and develops them through reading of the material.

2.8 Communication of results

The final step of the research process was the communication of synthesized (aggregated and substantiated) knowledge (valid and reliable answers to the research questions as well as further discussion). The results of the research were communicated to several target groups through several communication channels (Table 2.3).

Communication channels	Research Study	Description
Scientific journals	RS1	• Accepted for publication in *'Supply Chain Management: An International Journal'*
Conferences	RS1 RS2 RS3	• NOFOMA (2010, 2011, 2012) • 53rd Annual Transportation Research Forum in USA (RS2)
Seminars, courses, workshops, meetings	RS1 RS2 RS3	• Related seminars • Colleagues' courses • Research projects workshops and internal meetings
Book chapters and reports	RS1 RS2 RS3	• Book chapters in documents and reports of the research projects
Tools of web 2.0	Research main messages	• Blogs, social networks, podcast and videocast

Table 2.3 – communication channels in this research

Scientific journals

The research results have the potential to be published in different scientific journals (peer-reviewed and open access) in the disciplines of supply chain, logistics, transport, sustainability, environment, and urban studies. Paper I (result of RS1) was accepted for publication in *Supply Chain Management: An International Journal*.

Conferences

Conferences provided good opportunities to inform other researchers of the results of the three research studies as well as to ask for feedback. Papers I, II, and III corresponding to RS1, RS2, and RS3 were presented at NOFOMA (Nordic Logistics Research Network) Conferences in 2010, 2011, and 2012, respectively.

Seminars, courses, workshops, and meetings

All of the research results or parts were presented at several seminars, courses, research projects workshops and internal meetings by presentations, posters, and popular science articles.

Book chapters and reports of research projects

Some parts of Paper I and Paper II as well as a primary version of Paper III were published as book chapters in documents and reports of the research projects.

Tools of web 2.0

With the growing role of ICT in learning – sometimes called E-learning – new tools for communication of research and scientific information are emerging. Some tools of web 2.0, like blogs, social networks, podcast and videocast were also used for communication of some parts of research results.

2.9 Judging research quality

In line with Bryman and Bell's (2007) suggestions for evaluating qualitative research, two criteria were considered: trustworthiness and authenticity.

Trustworthiness

Trustworthiness has four aspects: credibility, transferability, dependability, and confirmability.

Credibility

"Credibility" parallels "internal validity" in quantitative research. It entails both "*ensuring that research was carried out according to the canons of good practice and submitting research findings to the members of the social world who were studied for confirmation that the investigator had correctly understood that social world*" (Bryman and Bell, 2007, p. 411). To increase credibility in RS1 and RS3, the corresponding papers were peer reviewed by editors of the journal of *Supply Chain Management: An International Journal* and the Øresund EcoMobility research project book, respectively. Paper II was also peer reviewed by editors of the NOFOMA 2011 and the TRF 2012 Conferences. In the second research study (RS2), the transcribed interviews were sent to interviewees for their confirmation.

Transferability

"Transferability" parallels "external validity" in quantitative research. It is concerned with the possibility of generalizing the findings beyond the research context or transferring to other milieu (Bryman and Bell, 2007). The main factor for increasing transferability was to generate representative samples of journals and papers (in RS1 and RS3) as well as interviewees (in RS2). In addition, the identified themes and challenges in RS1 are completely transferable to RS2 and RS3 as freight transport and urban distribution are sub-activities of supply chains.

Dependability

"Dependability" parallels "reliability" in quantitative research. It is concerned with applicability of findings at other times. To increase dependability during the research process, a research logbook/black box was created with complete records of every single phase of the research including: problems formulation, selection of samples, literature reviews, coding schedule and manual of contents analyses, protocols and databases of interviews, memos of open and focused coding, and data analysis procedures. However, qualitative subjectivity is inherited in the coding procedures of categories of themes and challenges. To decrease the probable bias, both writers of the articles performed the coding procedures and finally unified the emergent categories after several hours of discussion.

Confirmability

"Confirmability" parallels "objectivity" in quantitative research. As Bryman and Bell (2007, p.414) state: "*Confirmability is concerned with ensuring that the researcher can be shown to have acted in good faith; in other words, it should be apparent that he or she has not overtly allowed personal values or theoretical inclinations manifestly to sway the conduct of the research and findings deriving from it.*" The confirmability of the research has been assured as research logbook/black box was created, all the papers were peer-reviewed, and supervisors and other colleagues, teachers, and project workers controlled all or parts of the research studies.

Authenticity

In line with Bryman and Bell's (2007) suggestions for evaluating the authenticity of the research, the following criteria were considered:

Fairness

This is concerned with if the research fairly represents different viewpoints among members of the social settings. Diverse samplings of journals, articles, and interviewees as well as a sufficient number of them were measures to increase fairness authenticity.

Ontological authenticity

This is concerned with if the research helps the members to arrive at a better understanding of their social milieu. The research studies aimed to increase awareness of supply chain stakeholders about patterns of existing themes and challenges in sustainable development of their activities. During workshops and projects seminars, the involved stakeholders showed their satisfaction and how they were influenced by the findings of the research.

Educative authenticity

This is concerned with "*if the research helps the members to appreciate better the perspectives of other members of their social setting*" (Bryman and Bell, 2007, p. 289). Taking a holistic view of the entire supply chain as well as freight transport and urban distribution in the context of supply chains made the LSPs and projects members aware of the challenges experienced by other members of the network such as shippers (consignors and consignees), urban stakeholders, policy makers, decision makers, etc.

Catalytic authenticity

This is concerned with if the research acted as an impetus to members to engage in action to change their circumstances. Almost all the involved stakeholders agreed that this research has persuaded them that management, governance, development, and sustainable development of complex systems (like supply chains) call for a complexity theory perspective.

Tactical authenticity

This is concerned with if the research empowered the members to take the steps necessary for engaging in action. This research aimed to increase awareness about challenges and facilitate simultaneous operationalization of pillars of sustainable development in the context of supply chains from a new perspective (complexity theory perspective).

In addition, in line with the instructions of Grove et al. (2004), misconduct of the research by *fabrication* (making up data or results and recording or reporting them); *falsification* (manipulating research materials, equipment, or processes, or changing or omitting results such that the research is not accurately represented in the research record); or *plagiarism* (both the theft or misappropriation of intellectual property and the substantial unattributed copying of another's work) was completely avoided.

3. FRAME OF REFERENCE

"Most of the fundamental ideas of science are essentially simple, and may, as a rule, be expressed in a language comprehensible to everyone."

Albert Einstein

This chapter presents a brief explanation of the main concepts discussed during the research journey. In addition, my standpoints on these concepts are clarified.

The building blocks of the research studies and discussion chapter are a set of concepts that were adopted from different disciplines. These concepts represent the labels that were given to the elements of the social world – that seem to have common features (Bryman and Bell, 2007, p. 158) – around which the research was conducted. This chapter provides a brief explanation of the main concepts of this research.

3.1 Supply chains and sustainable development

In order to reflect on different parts of Figures 1.4.a and 1.4.b, several concepts related to supply chain management, sustainable development, and sustainable supply chains were studied. The following sub-sections (shown in Figure 3.1) explain these concepts in more detail.

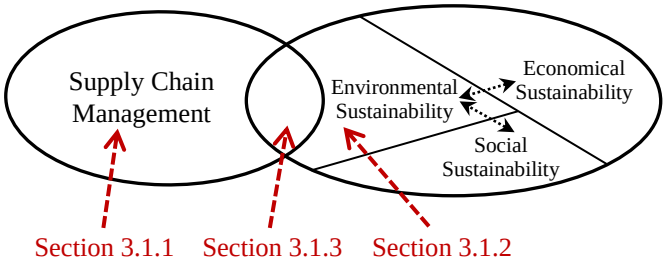

Figure 3.1 – Standpoint on supply chains and sustainable development

3.1.1 Standpoint on supply chain discipline

"Supply chain" is a concept that has evolved through several fields (Stock and Boyer, 2009) and been defined from different perspectives (Halldórsson et al., 2008) and hence lacks a comprehensive and encompassing definition.

According to Mentzer et al. (2001, p.4), a supply chain is defined as "*a set of three or more entities (organization or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer*". However, in practice, a supply chain is a network of multiple businesses and relationships more than just a chain of businesses with one-to-one, business-to-business relationships. A supply chain involves activities in delivering a service or product from raw material to the customer including:

- sourcing raw materials and parts (procurement)
- forecasting
- manufacturing and assembly
- production
- warehousing/storing and inventory tracking
- order entry and purchasing

- transportation and distribution across all channels
- packaging and materials handling
- marketing
- sales
- delivery

Supply chains are also referred to as "demand chain", "value chain", and "supply/demand/value network" (Vitasek, 2010; Christopher, 2005).

The art of supply chain is its management (SCM). This includes planning, control, review, coordination, cooperation, integration, and organization of key business processes, relationships, channels partners (Lambert and Cooper, 2000; Vitasek, 2010), flows (materials, information, resources, and finance), and services across the chain from materials extraction to consumption (i.e. the supplier/s to the customer/s).

According to Simchi-Levi et al. (2004, p.1), *"Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying service level requirements".*

The objectives of SCM can be several like:

- value creation, increasing efficiency, customer satisfaction (Stock and Boyer, 2009; Fawcett and Fawcett, 1995)
- reduction or minimization of total or transactions costs (Schonsleben, 2000; Hall and Matos, 2010)
- improved total quality (Schonsleben, 2000)
- competitive advantage (Mentzer et al., 2001)
- maximized profitability for the company and the whole supply chain network including the end-customer (Lambert et al., 2008)

"Logistics management" is another concept which is defined as *"that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements"*(Vitasek, 2010). Logistics management activities typically relate to flows in supply chains including management of inbound and outbound transportation, inventories, warehousing, materials handling, and service providers. Logistics in this research is treated from a unionist perspective to SCM (Halldórsson et al., 2008) as the former is subsumed by the latter. In this sense, supply chain management goes one step further than logistics management by integrating key business processes and relationships, rather than just flows, across the chains (Lambert and Cooper, 2000).

"Distribution" is another concept that was mostly discussed in research study 3 (RS3). It is related to outbound movement and storage of finished products (McKinnon et al., 2010) associated with movement from a manufacturer or distributor to customers, retailers or other secondary warehousing / distribution points (Vitasek, 2010). Although distribution is related to outbound logistics related to downstream activities of a supply chain from a specific organization (Gripsrud et al., 2006), the third research study (RS3) took a more holistic view of aggregated distribution of several chains or organizations in an urban context.

Themes and challenges in making freight transport sustainable was the subject of the second research study (RS2). Transport in this study was defined as physical movement of goods from a consignor (shipper/ sender/ hollow/ sink [outbound gateway]) to a consignee (receiver/ source [inbound gateway]). Themes and challenges were studied from selected logistics service providers. "Logistics service provider" (LSP) refers to any business that provides logistics services such as:

- transportation, storage, and warehousing (Wolf and Seuring, 2010)
- packaging, freight forwarding, and inventory management (Liu et al., 2006)
- cross-docking at terminals, consolidation services at distribution centers, and transload of shipments (Vitasek, 2010; Sternberg, 2008)
- managerial activities related to flows of goods and production (Fabbe-Costes et al., 2009)
- value-added activities such as merge-in-transit setups (Stefansson, 2006)

Outsourcing logistical activities to LSPs is rapidly growing (Gripsrud et al., 2006), although the degree of outsourcing varies and the outsourced activities differ greatly in complexity (Stefansson, 2006). LSP is also referred to as "third-party logistics (3PL)", "fourth-party logistics (4PL)", "lead logistics partner (LLP)", "third-party logistics provider", and "third-party service provider (3PSP)" (Vitasek, 2010). Fabbe-Costes et al. (2009) provide a wide range of names and phrases used to denote a LSP.

"Packaging logistics" is another concept that was reflected on during the research process. It deals with interactions between packaging systems and logistics systems (Hellström, 2007). Such interactions are investigated by analyzing the effects of logistics systems on packaging systems (products as well as primary, secondary, and tertiary packages) and vice versa. Saghir (2004, p. 6) defines packaging logistics as: *"The process of planning, implementing and controlling the coordinated packaging system of preparing goods for safe, efficient and effective handling, transport, distribution, storage, retailing, consumption and recovery, reuse or disposal and related information combined with maximizing consumer value, sales and hence profit."* All levels of the packaging system were in focus during the second and third research studies when freight transport and distribution were studied, respectively. With regard to this, goods (freight) were not solely related to work-in-process or finished products but also to the packaging system around them and the unit loads carrying them.

3.1.2 Standpoint on sustainable development discipline

"Sustainable", according to the Oxford Dictionary, is defined as "*able to be maintained at a certain rate or level*" or "*able to be upheld or defended*." According to the same dictionary, "development" is defined as "*the process of developing or being developed*" or "*a specified state of growth or advancement*" or "*a new and advanced product or idea.*" Sustainable development in a general sense is thus related to a growth or development that can be continuously maintained or upheld.

The origins of the "sustainable development" concept date back to the mid-1960s and early 1970s, especially after the 1972 UN Conference on Human Environment in Stockholm, (Mebratu, 1998) when the concept of sustainable development evolved from purely an environmental focus (such as environmental assessment and management) and appeared among professionals in environment and development circles (Björklund, 2005). It was then that environmental and developmental ideas were concurrently considered and terminologies such as "environment and development", "development without destruction", "environmentally sound development", and "eco-development" were used.

In 1987, a United Nations sponsored report published by the Commission on Environment and Development (WCED) and entitled *Our Common Future*, also known as the *Brundtland Report*, popularized the term and provided it with its widely known definition: *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."* According to Mebratu (1998), major internationally related documents such as the "*Rio Declaration"*, "*Agenda 21"*, and "*conventions on desertification, biodiversity, and climate change"* were produced at the UN Conference on Environment and Development (UNCED) also known as the Rio Conference or the Earth Summit held in June 1992. Following the United Nations' 2005 World Summit, sustainable development encompasses the interdependent and mutually reinforcing pillars of economic development (Profit), social development (People) and environmental protection (Planet). The three pillars or Ps of sustainable development are also called the "three bottom lines" or "triple bottom lines" (TBL or 3BL).

Sustainable development is also referred to by similar concepts such as "corporate sustainability" (MacLean, 2010; Jeffers, 2010), "corporate responsibility" (Zwetsloot, 2003), or just "sustainability" (Aras and Crowther, 2009; Shrivastava, 1995).

The environmental protection pillar of sustainable development is also labeled as "environmentally sustainable/friendly/sound/preferable/responsible", "eco", and "green". The term "environment" in this regard is related to the natural environment rather than the business or organizational environments (Aras and Crowther, 2009), which are exponentially discussed among contingency theorists (Zacharia and Mentzer, 2004; Pfohl and Zöllner, 1997).

In recent years, sustainable development has become a buzzword for various activities ranging from protecting the environment, reducing negative environmental impacts and pollutions, protecting endangered species, saving natural resources and energy, ending poverty, eradicating hunger, achieving universal primary education, improving health, job creation, achieving social amenity and equity, to economic growth, global trade, financial effectiveness, achieving economic equity, improved marketability, education for sustainable development, lifelong learning; and – as Aras and Crowther (2009) state – "*everything necessary for maintaining the Earth as a planet capable of sustaining life. (...) Sustainability implies that society must use no more of a resource than can be regenerated."*

Sustainable development also carries a label for climate change, natural ecology, energy, vulnerability to droughts, fast desertification, scarcity of water, pollution, deforestation, crop failure, health, safety, land degradation, chemical food adulteration, social responsibility, social/economic/political justice, gender equality, humanity, human rights, cultural diversity, peace, conflicts resolutions, poverty, full and active citizenship, migration, bio-social-cultural diversity, and distribution of power.

Although the three inter-dependent and equally necessary pillars of sustainable development were originally defined from a macro level of society (the entire world or a nation [Aras and Crowther, 2009]) and economy, they are equally relevant at the micro level of the society/corporation or economy. Triple bottom lines are increasingly appearing in literature on business, management, engineering, organization, and operations disciplines (Unruh, 2009; Carter and Rogers, 2008; Aras and Crowther, 2009; Byrch et al., 2007) and are adapted by industries and companies (MacLean, 2010; Carter and Rogers, 2008).

However, it is extremely difficult to explain the multi/inter/trans-disciplinary concept of sustainable development (from a micro perspective) in concrete terms (Venkataraman, 2009; Viezzer, 2006) or operationalize/implement it (Bowen et al., 2001) especially when it comes to a holistic view of all aspects and the interconnection of its pillars (MacLean, 2010).

Research and education for sustainable development can play an important role in moving the concept of sustainable development beyond UN terminology into practice (Venkataraman, 2009; Viezzer, 2006; Jeffrey and Walter, 2006; Unruh, 2009; Dale and Newman, 2005). According to Venkataraman (2009, p.8), education for sustainable development differs from environmental education. The latter focuses on *"humankind's relationship with the natural environment and on ways to conserve and preserve it and properly steward its resources"* while the former *"encompasses environmental education but sets it in the broader context of socio-cultural factors and the socio-political issues of equity, poverty, democracy and quality of life."*

3.1.3 Developing sustainable supply chains

The literature on sustainable supply chains has co-evolved with the concept of sustainable development by growing from a purely environmental/green perspective to a wider sustainability perspective. Increasing numbers of businesses and companies are also publishing sustainability reports and codes of conducts (Andersen and Skjoett-Larsen, 2009) in contrast to the primary focus on environmental reporting (Carter and Rogers, 2008).

Sustainable supply chains have been treated in the literature in various ways. Some literature reflects on the embodiment of some or all the pillars of sustainable development in the context of supply chains and presents such concepts as:

- corporate social responsibility (Keating et al., 2008; Dyllick and Hockerts, 2002; Andersen and Skjoett-Larsen, 2009; Markley and Davis, 2007; Defee et al., 2009)
- social responsibility (e.g. diversity, philanthropy, human rights, and safety [Carter and Easton, 2011; Carter and Jennings, 2002])
- corporate environmental responsibility (the ecological dimension of corporate social responsibility [Kovács, 2008])
- green supply chains (Abukhader and Jönson, 2004; Mollenkopf et al., 2010).

According to Abukhader and Jönson (2004, p. 146), *"green supply chain is mainly a discussion about assessment of the impact of environment on logistics. It evolves discussion of how implementing environmental measures would influence, negatively or positively, the logistics/supply chain infrastructure, and how we can find win-win solutions so that we satisfy the government regulations, satisfy the end customers and stay cost-effective."*

The underlying assumption in the literature is the economical sustainability of supply chains. In other words, the literature takes the economic feasibility of supply chains as a warrant for long-term sustainability and elaborates mostly on other pillars of sustainable supply chains.

Other literature discuses sustainable supply chain activities such as:

- green logistics (McKinnon et al., 2010; Aronsson and Huge Brodin, 2006; Ping, 2009; Chunguang et al., 2008)
- environmental logistics (Wu and Dunn, 1995)
- green purchasing (Min and Galle, 1997; Björklund, 2005)
- green marketing (MacLean, 2010; Kirchoff et al., 2011)

- reverse logistics (Zikmund and Stanton, 1971; Bernon et al., 2011)
- carbon auditing of supply chains including products and companies (McKinnon, 2010; McKinnon et al., 2010)
- energy efficiency (Halldórsson and Kovács, 2010) including transport energy efficiency and emissions (McKinnon et al., 1993)
- environmental assessment (Jones, 2002; Merrick and Bookbinder, 2010)
- sustainable procurement (Walker and Brammer, 2009; Preuss, 2009)
- sustainable mobility (Banister et al., 2000; World Business Council for Sustainable Development, 2004)
- sustainability oriented innovation and entrepreneurship (Peters et al., 2011, Isaksson et al., 2010)
- sustainable transport (Gudmundsson and Höjer, 1996)
- green supply chain management (Klassen and Johnson, 2004; McKinnon et al., 2010; Srivastava, 2007; Kirchoff et al., 2011)
- sustainable supply chain management (Carter and Rogers, 2008; Carter and Easton, 2011; Svensson, 2007)

Carter and Rogers (2008, p. 368) define sustainable supply chain management as *"the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual company and its supply chains."* Klassen and Johnson (2004) describe "green supply chain management" as the alignment and integration of environmental management within supply chain management. According to McKinnon et al. (2010), the origins of green supply chain management can be traced back to two functional areas in which companies' environmental responsibilities interfaced with external agencies: green purchasing/supply and reverse logistics. Reverse logistics deals with the role of logistics in product returns, source reduction, recycling, materials substitution, reuse of materials, waste disposal and refurbishing, repair, and remanufacturing (Stock, 1998).

Green supply chains, and logistics more specifically, have developed from reverse logistics to closed-loop supply chains combined with GHG emissions and ecological footprints consideration. The perspectives have also evolved from public-to-private, operational-to-strategic, and local-to-global (McKinnon et al., 2010). As Defee et al. (2009) reflect: "*Closed-loop supply chains require the strategic integration, planning, and operation of both forward and reverse flows of supply chains operated by a firm. (...) It includes three major themes; namely 'returns management, product acquisition and asset recovery', 'issues of remanufacturing', and 'secondary markets and channel design'.*"

There is also literature that investigates the effects of logistical concepts on sustainability of supply chains such as the environmental effects of online versus conventional shopping (Edwards et al., 2010; Sarkis et al., 2004), postponement (Yang et al., 2005), virtual logistics (Clarke, 1998), logistics structure decisions (Aronsson and Huge Brodin, 2006), and carbon intensity and footprints of "last mile" deliveries (Edwards et al., 2010).

Hence, in this thesis, sustainable development of supply chains is more explicitly related to environmental than social aspects. However, the analysis is related to the environmental effects of aggregated supply chains activities (interaction between micro and macro levels of economy and society) rather than supply chains activities of a specific company or organization (purely micro levels of economy and society).

3.2 Supply chains and complexity

In order to reflect on the complexity theory perspective, shown in Figures 1.4.a and 1.4.b, several concepts related to complexity theory and the science of complexity as well as supply chain complexity were studied. The following sub-sections (shown in Figure 3.2) explain these concepts in more details.

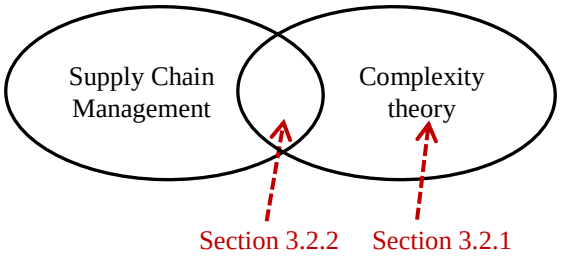

Figure 3.2 – Standpoint on supply chains and complexity

3.2.1 An overview of complexity theory

Complexity theory is the theory of complex systems. As Allen and Strathern (2003, p.8) state, it is a "scientific" theory of change and transformation, (…) without it "*social and organizational change could only be driven by trial and error and by people's accumulating experience and confusion.*" Complexity theory challenges the Newtonian, reductionist, and positivist rationale of science and "*suggests that it is in the dynamic interactions and adaptive orientation of a system that new phenomena, new properties and behaviors emerge; that new patterns are developed and old ones change (...) Complexity theory seeks the sources of and reasons for change in the dynamic complexity of interactions among elements or agents that constitute a particular environment*" (Mason, 2009, p.119).

Complexity theory provides a gaze (perspective and paradigm) for the study of complex systems. Although it is hard to sharply define complex systems, they are characterized as:

- being constituted of many elements/components/parts/sub-systems/agents
- having components that are tightly coupled with nonlinear interactions among them
- being open, dynamic, and governed by feedback loops
- having self-organizing, emergent, and evolutionary attributes

Some of these characteristics are briefly explained in what follows.

Interwoven with nonlinear interactions

Both complicated and complex systems consist of a number, often very high, of interwoven/interrelated components. The difference between complicated and complex systems is in the nature of the interactions among the components, as the former have only linear while the latter have both linear and nonlinear interactions.

Due to nonlinearity, causes are not directly proportional to their effects. Small variables over a period of time can lead to major changes in a non-linear system. This means that complex systems are not completely predictable (Gershenson and Heylighen, 2004). In complex systems, interactions are also highly sensitive to the history of the components and to their current context (Hogue and Lord, 2007).

Nevertheless, it is important to realize that because a system is not predictable in the long term, does not mean that it is impossible to understand or even to explain its behaviors (Kauffman, 1995). Complex systems reveal patterns of behavior over a longer time period.

Openness
Complex systems are open, which means that they operate under conditions far from equilibrium (Stacey et al., 2000, p. 18). The state of the system is determined by the values of its inputs and outputs (Cilliers, 2005) or continuous flows of energy and resources passing through them. Openness and the need of energy is a generative process of self-organization in complex systems (Prigogine, 1997).

Self-organization
This relates to the ability of a complex system to spontaneously generate new internal structures and forms of behavior by arranging its components and their interactions into sustainable, global structures that try to maximize overall fitness, without the need for an external or internal controller (Kauffman, 1995). In the self-organization process, the components interact/communicate with neighboring components and spontaneously re-orientate and restructure their relationships with them. As a result of this process, the components dynamically achieve a global function or behavior (Gershenson, 2007) by intrinsically seeking order (i.e. coherent patterns) (Nilsson, 2003). According to McMillan (2006), "*spontaneity is an important feature of self-organizing systems as they interact and reshape themselves. The ability to spontaneously self-organize, for example, enables fish to shoal to protect themselves from predators, birds to flock for foraging or protection, and social ants and termites to organize themselves so that their nests or mounds are built and their young fed.*" Self-organization shifts the complex systems towards the edge of chaos where creativity and change is appreciated.

Emergence
This relates to the capability of a complex system to show macroscopic properties that are distinct from the microscopic properties of its individual components and their interactions. In other words, the whole is more than (and certainly different in kind to) the sum of its parts (Bar-Yam, 1997; Merali, 2006; Letiche, 2000; Reitsma, 2001; Cilliers, 2005). As Nilsson (2003, p. 20) states: "*emergence could be addressed as the outcome of collective behavior i.e. self-organization of several units, elements or human beings i.e. agents, performing something individually, or together, that creates some kind of pattern or behavior that they themselves cannot produce.*" According to Mason (2009, p.119), "*new properties or behavior emerge when sufficient numbers and varieties of constituent elements cluster together to form a sufficiently complex arrangement of incredible scale. Once a system reaches a certain critical level of complexity, otherwise known as the critical mass, a phase transition takes place which makes possible the emergence of new properties and behaviors and a new direction of self-sustaining momentum.*"

In addition to the above characteristics, some complex systems also have adaptive characteristics. These systems are referred to as complex adaptive systems (CAS) (Nilsson 2003, 2005; McMillan, 2006) which have the following characteristics.

Adaptation
Complex adaptive systems (CAS) are self-organizing systems that *learn* to adapt to changes in circumstances. They are "*pattern seekers which interact with their environment, learn from their experiences, and then adapt"* (Gell-Mann, 1994); they do not respond passively to events, but they actively seek benefits from any situations (McMillan, 2006). In other words, they can anticipate the future (Holland, 1992) by learning from the past patterns in time (Nilsson, 2005). Adaptation at the macro level (the "whole" system) is characterized by emergence and self-organization based on the local adaptive behavior of the system's

constituents (Merali, 2006). According to Nilsson (2003), complex adaptive systems consist of interdependent, connected, and heterogeneous parts and entities (called agents). To be adaptive, some of the agents of the complex systems must have the property of agency (the ability to interact meaningfully in the course of events). Dynamic interactions among the heterogeneous agents make them robust (Gershenson, 2007) and innovative (Allen, 2000).

Some researchers put the finger on the ability of complex adaptive systems to adapt without a controller (Holland, 1995; Nilsson, 2003; 2005). According to Choi et al. (2001), a complex adaptive system "*emerges over time into a coherent form and adapts and organizes itself without any singular entity deliberately managing or controlling it.*"

Schemas and rules

Stacey (1996) sets down three important parameters that describe complex adaptive systems: *"the rate of information flow through the system"*, *"the richness of connectivity between agents in the system"*, and *"the level of diversity within and between the schemas of the agents."* According to Nilsson (2003, p.25), "*an agent's schema is commonly referred to norms, values, assumptions, and mental images which are part of the paradigm i.e. derived and interpreted from the collective of agents.*" The schemas influence the behavior of agents of complex adaptive systems while they are reacting to changes in their environments or creating their local surroundings.

Co-adaptation and co-evolution

Complex adaptive systems have reflexive relationships with their surrounding environments (any type of environment): changes in the system both shape and are shaped by changes in the environment. The dynamic and mutual interrelationships among complex adaptive systems and environments take us from issues of simple adaptation and evolution to issues of co-adaptation and co-evolution in dynamic contexts (Merali, 2006). Schemata of complex adaptive systems co-adapt and co-evolve with those of their surrounding environments.

3.2.2 Complexity theory in supply chains

As supply chains are complex systems (Nilsson, 2003; 2005; Abbasi, 2008) they can be studied from a complexity theory perspective. It is through this perspective that the nonlinearities, interrelationships, changes, learning and innovative capacities, dynamics, and paradoxes existing in complex supply chains can be studied. Without such a perspective, management of their agents becomes completely regulatory, completely objectivist, hierarchical, linear, reductionist, and positivist where every process and activity must be run as fast as possible. Furthermore, the relations and mutual effects among the agents and their surrounding environments become neglected or inaccurately understood.

Nilsson (2005) elaborates on two branches of complexity theory: complex adaptive systems and complexity thinking which are more explicitly discussed in the context of logistics and supply chains. Tracks of complexity theory can be found in several dimensions of supply chains such as:

- transportation and logistics (Waidringer, 2001; Nilsson, 2003, 2005; Abbasi, 2008)
- manufacturing and logistics (Nilsson and Darley, 2006; Wu et al., 2007; ElMaraghy and Urbanic, 2003; ElMaraghy et al., 2005)
- production (Wu, 2000)
- operations management (Baldwin et al., 2010)
- supply base (Choi and Krause, 2002)
- warehousing (Faber et al., 2002)

- organizational learning (Allen, 2002; Siemieniuch and Sinclair, 2002; Keene, 2000; Browaeys and Baets, 2003; McKenna, 1999; Backlund, 2002; Cunha and Cunha, 2006)
- information systems (Jacucci et al., 2006; Merali and McKelvey, 2006; Merali, 2006)

In the following, some characteristics of complex supply chains are briefly explained.

Various heterogeneous components and activities

Supply chains are constituted of a very high number of heterogeneous components, activities, and processes that are dynamically increasing. This relates to complicated characteristics of complex supply chains, which are mostly addressed in common logistics and supply chain literature (Nilsson, 2003, 2005; Abbasi, 2008). Components are related to focal companies, suppliers, customers, distribution centers (terminals, hubs, consolidation centers, etc.), warehouses, retailers (outlets), transport actors, logistics service providers, resources, goods (materials, packages, inventories, products, etc.), humans, and so on. On the other hand, activities and processes may relate to different production and manufacturing, procurement and purchasing, inventory control, distribution, and reverse logistical methods, several regulations, standards, and laws, services, etc.

In addition, the sub-systems (components) are themselves complex systems that may have an attribute of complexity or just complication. For example, a focal company is itself a complex system as it may be constituted of several assembly lines, workstations, resources (staffs, tools, assets), departments, and so on and so forth. Each component may also belong to supply chains of different supply networks. "*Diversity can be hugely advantageous in terms of innovative capabilities if set within a conducive organizational culture*" (Jarratt, 1999). "*It also has the potential to radically affect the evolution of a company particularly in times of change*" (Baldwin et al., 2010).

Nonlinear interaction

The philosophy of supply chains is to increase interactions among its components through cooperation, coordination, integration, connectivity, and collaboration. In addition, these interactions are nonlinear as small variables over a period of time can lead to major changes in supply chains. The bullwhip effect is a well-known example of nonlinearity in supply chains (Datta, 2004). Another example is the tremendous reduction of transport and traffic intensity and as a result negative environmental impacts by small changes in dimensions and materials of packages (Olsson and Larsson, 2009). Another example is nonlinear relation between vehicles' speed and fuel consumption (McKinnon et al., 2010, p. 130) in transportation.

Openness

Supply chains are open systems with continuous flows of goods, resources, information, and finance passing through them. Flows of goods relate to huge amounts of materials and products (raw materials, in-process and finished products) as well as packages (primary, secondary, and tertiary) moving across networks of supply chains. There are also significant numbers of movable resources like humans and machines (unit loads and cargo carriers, vehicles, robots, machineries, etc.).

Supply chains are open to both horizontal and vertical flows of data and information as well as finance (currencies, credits, deposits, etc.) passing through them. This openness makes the supply chains dynamic and able to self-organize.

Self-organization
In well-connected open supply chains, the components (sub-systems) interact with each other in order to spontaneously (re)generate global structure in order to fulfill values of their chain(s). This characteristic makes the supply chains follow different strategies to fulfill their customers' demands in different markets. In order to self-organize, the components of the chain must have enough freedom to have interaction with other components of their networks outside their functional boundaries. Because of this, the components can reorient themselves and adjust their operations and strategies without having determined restricted top-down rules from supply chain orchestrators. The process of self-organization lets the components think out of the box by appreciating dynamics, change, and innovation necessary for shifting the supply chains towards the edge of chaos.

Emergence
Values in the supply chains emerge as the patterns of local interactions of supply chain components in a local context. The emergent values are different from characteristic(s) of each supply chain component. The values are generated as a result of a self-organization process among the component. With regard to this, in order to study supply chain performance and values, holistic assessments of the interactions among the components must go beyond assessment of performance of each component in isolation. Thanks to emergence, values can be generated even if some components of the chain or network on some occasions might show other values.

Although too much control detracts supply chains from innovation and flexibility, allowing too much emergence can undermine managerial predictability and work routines (Choi et al., 2001). Management of supply chains requires a balance between control (letting the predefined values emerge) and emergence of patterns of new positive properties.

Some types of complex supply chains have also "agency" characteristics. These types of supply chains can be studied through a complex adaptive systems perspective.

Adaptive supply chains
Some researchers see the need to recognize supply chains and logistics as complex adaptive systems (Choi et al., 2001; Nilsson, 2003, 2005; Wycisk et al., 2008). Supply chains are CAS as they have some components with characteristics of agency (like intelligent resources [humans, machineries] and goods) which are able to intervene meaningfully in the course of events. The agents also have schemata (norms, values, beliefs, and assumptions that are shared throughout the whole system) and are in connection (interrelationships) with other agents. Existing rules, regulations, and schemata help the agents to act more predictably and cybernetically. However, giving more freedom and a higher degree of autonomy to the agents increases the probability of the emergence of innovative properties.

In addition, a supply chain emerges without any firm deliberately organizing and controlling it. Recognizing supply chains as CAS can also help to study the changing boundaries of the system and mutual effects of changes between the system and its surrounding environments (Choi et al., 2001; Nilsson, 2005). Supply chains redesign their strategies and restructure their operations by learning from emerging patterns of trends, technologies, and supporting infrastructure. Supply chains co-adapt and co-evolve by, for example, advancement in transport and communication infrastructures, new energy resources, tools and machineries, new rules and laws, and production as well as consumption patterns.

Complexity thinking is another branch of complexity theory that is suitable for the study of paradoxes in supply chains.

Paradoxes in supply chains

According to Stacey (2000, p. 328) a paradox "*may mean an apparent contradiction, a state in which two apparently conflicting elements appear to be operating at the same time."* Another way to define the term *paradox* is in line with Hegel's dialectical logic. Here the term *"paradox means the presence together at the same time of contradictory, essentially conflicting ideas, none of which can be eliminated or resolved"* (ibid., 2000, p. 328). As Nilsson (2005, p.36) puts forward, "*In such a situation there is no way the paradox can be resolved or eliminated by positivistic assumptions and claims, and therefore a different kind of logic is needed; a logic of a dialectic character.*" Nilsson (2005, p. 49-63) provides a thorough list of paradoxes which are apparent all the time in logistics research and practice, namely the efficiency/effectiveness paradox, the paradox of control, the paradox of optimization, and the cooperation/competition paradox.

4. RESULTS

"The value of a man should be seen in what he gives and not in what he is able to receive."

Albert Einstein

This chapter presents a summary of the appended papers that are the results of the three research studies (RS1, RS2, and RS3). Each paper provides trustworthy and authentic answers for its corresponding research question.

During the first research study, five major themes and challenges in making supply chains environmentally sustainable were identified. The second research study led to identification of fifteen and five major themes and challenges, respectively in making freight transport sustainable. In context of urban freight distribution, these numbers were eight and seven, respectively.

4.1 Themes and challenges in making supply chains environmentally sustainable

The systematic review of selected articles and by running inductive content analysis led to the identification of major themes and challenges in making supply chains environmentally sustainable.

4.1.1 Identified themes

Five major themes emerged during the first research study, namely, management issues; green activities, policies, and strategies; reverse logistics/closed-loop supply chains; concept of sustainable supply chains; transport fuel, energy and emissions. The extract of the grouped themes are illustrated in Table 4.1. For detail explanation of each major theme please refer to the first appended paper.

Management issues	• Environmental and sustainability assessment, measurement, monitoring, analysis, and evaluation of supply chains activities/concepts
Green activities, policies and strategies	• Explanation of concept and trends of green supply chains • Green activities and processes of green supply chains • Strategies and policies for management or development of green supply chains
Reverse logistics/close-loop SC*	• Analysis of one or some aspect(s) of reverse logistics • Conceptual development of closed-loop supply chains
Concept of sustainable SC*	• Study of embodiment of the three bottom lines of sustainable development in the context of supply chains
Transport fuel, energy and emissions	• Reducing transport- emissions, and fuel/ energy use

Table 4.1 – The five major themes in making supply chains environmentally sustainable
(SC* = Supply Chains)

4.1.2 Identified challenges

During the process of synthesising the content of the reviewed literature, a number of challenges in making supply chains environmentally sustainable emerged.

While several specific and detailed challenges were raised, the synthesis resulted in five major categories of challenges as illustrated in Table 4.2. These five categories were: costs; complexity; operationalization; mindset and cultural changes; uncertainties. For detail explanation of each category of challenges please refer to the first appended paper.

Costs	• Increasing financial costs in reducing negative environmental impacts • It must financially pay to be green • Quantifying environmental costs of operations/processes/activities
Complexity	• Diagnose of environmental aspects/effects of operations/processes/activities • Diagnose of social aspects/effects of operations/processes/activities • Measurement/assessment of environmental effects of operations/processes/activities • Measurement/assessment of social effects of operations/processes/activities • Conflicts of a paradoxical character in sustainable development of supply chains
Operationalization	• Interpretation of dimensions of sustainable development in operations/processes/activities • Inertia against development of environmentally sustainable operations/processes/activities • Inertia against development of socially sustainable operations/processes/activities
Mindset and cultural-changes	• Change of mind-sets/culture/values on international-, national-, and organizational levels • Making customers aware of dimensions of sustainable development • Change of customers' behaviour/mind-sets/culture/values • Making decision-makers aware of dimensions of sustainable development • Change of decision-makers' behaviour/mind-sets/culture/values • Making co-workers aware of dimensions of sustainable development • Change of co-workers' behaviour/mind-sets/culture/values
Uncertainties	• Uncertainties to the degree and nature of governmental regulations and policies • Uncertainty in long-term development • Uncertainties in consumers' behaviour and demands • Uncertainties in competitive advantages and strategies formulated by stakeholders

Table 4.2 – The five major challenges in making supply chains environmentally sustainable

4.2 Themes and challenges in making freight transport sustainable

After as well as in parallel with data collection (interviews with selected Logistics Service Providers [LSPs] and literature review), data analysis was run in order to find trustworthy and authentic answers for the second research question. The analysis after focused coding and then categorizing/clustering them led to identification of themes and challenges. Themes in the second research study were divided into current and future activities.

4.2.1 Identified current activities

The analysis of current activities resulted in emergence of eight major categories (summarized in Table 4.3). Three of these were most emphasized by most of the interviewees (primary activities) while the other five were less emphasized (secondary activities). The primary activities were: resources efficiency, effectiveness, and utilization; environmentally/ sustainability cautious behavior; measurement and assessment. The secondary activities were: taking initiatives; compliance with legislations and standards; efficient utilization of transport infrastructure; well-connected information and goods flows; vertical and horizontal collaboration. For detail explanation of each current activity please refer to the second appended paper.

Primary activities	**Resources efficiency, effectiveness, and utilization**	• Efficient- and effective movable resources (right mode of transport (intermodality), using environmentally friendly vehicles) • Efficient static resources (energy- and eco-efficiency in terminals, hubs, distribution centres, warehouses, offices, etc.) • Higher resource utilization (by increasing load factor, fill-rates, efficiency, etc.)
	Environmentally/ sustainability cautious behavior	• Educating and training the stakeholders (like personnel) about ethically- and environmentally friendly operations • Responsible sourcing/procurement (scanning all suppliers to assure that they fulfil social and environmental (corporate social responsibility) requirements)
	Measurement and assessment	• Internal standards and scorecards to measure/assess sustainability related parameters • Online platform for calculation of GHG emissions from transport operations • Publishing annual sustainability reports
Secondary activities	**Taking initiatives**	• United Nations (UN) Global Compact initiative • United Nations Development Program (UNDP) initiative • Logistics Emergency Teams (LET) initiative
	Compliance with legislations and standards	• Following organizational, national, continental, and/or global legislations/ requirements/standards *(Like ISO 14001, EMAS certification, Sulfur emission- and Ballast water legislations by IMO)*
	Efficient utilization of transport infrastructure	• Using up-to-date technologies/devices/software for route-planning & optimization • Coordinated air traffic control and single sky in air sector
	Well-connected information and goods flows	• Implementing Intelligent Transport and Track and Trace systems
	Vertical and horizontal collaboration	• Collaboration and Lobby work with other LSPs, authorities, and stakeholders

Table 4.3 – Current activities in making freight transport sustainable (LSPs' perspective)

4.2.2 Identified future activities

All the interviewees agreed upon tremendous difficulty and uncertainty in design of future sustainability-related activities and strategies for freight transport in a long-term perspective like 40 years from now (till 2050). However, a few of them (the larger LSPs) took a shorter perspective (till 2020) to elaborate on future activities and strategies.

The analysis of future activities resulted in emergence of seven major categories (summarized in Table 4.4). Three of these were most emphasized by most of the interviewees (primary activities) while the other four were less emphasized (secondary activities). The primary activities were: innovation and research; energy/fuel efficiency; increasing awareness. The secondary activities were: technological development; design for sustainability; adaptation to future policies and corporate governance; taking supply/value chain view.

Worth mentioning that all LSPs are going to continue their current activities in making freight transport sustainable mentioned in section 4.2.1. For detail explanation of each current activity please refer to the second appended paper.

Primary activities	**Innovation and research**	• Openness to innovative- solutions/ strategies/ out of the box ides/ business models • Invest in research and collaboration with researchers and advisory councils
	Energy/fuel efficiency	• Utilizing resources (vehicles and facilities) fed by non-fossil/renewable while economic fuels • Collaboration with vehicle manufacturers (designing environmentally friendly trucks, trains, vessels, and aircrafts) • Collaboration with base industries (moving towards zero emission from energy production and consumption) • Benchmarking energy efficiency with other businesses
	Increasing awareness	• By collaborating with other stakeholders in organizational, national, regional, and international levels
Secondary activities	**Technological development**	• Like development or adaptation of Transport Management Systems (TMS), Intelligent Transport Systems (ITS), Enterprise Resource Planning (ERP), future generation of vehicles
	Design for sustainability	• Better design of supply chain statics like number and arrangement of terminals, hubs, distribution centers, etc.
	Adaptation to future policies and corporate governance	• Collaboration with authorities and policy makers regarding coming policies and directives (like CO_2 tax, emissions right, emissions trading, emissions restrictions)
	Taking supply/value chain view	• Collaboration with products' producers/manufacturers and consumers as well as passenger carriers (both horizontal & vertical collaboration with upstream & downstream actors)

Table 4.4 – Future activities in making freight transport sustainable (LSPs' perspective)

4.2.3 Identified challenges

In total, five major categories of challenges in making freight transport sustainable, out of LSPs' perspective, were identified (Summarized in Table 4.5). These five categories were: business complexity; time and cost; managerial complexity; network imbalances; uncertainties.

For detail explanation of each category of challenges please refer to the second appended paper.

Business Complexity	• Difficulty of cooperative sustainable development due to fragmented nature of logistics industry • Low sustainability interest of the customers • Low united sustainability interests inside LSPs (especially the global ones)
Time and Cost	• LSPs customers usually look at transport as a non-value activity which must be fulfilled with lowest time and price
Managerial Complexity	• Difficulties in measurement and assessment of environmental externalities • Different standards, methods, and platforms for measuring GHG emissions or assessing environmental impacts • Different customers' demand in different markets and industries • Difficulties in change and adaptation in favour of sustainability
Network imbalances	• Restrictions in delivery times, diverse load and unload (pick and delivery) operations • Geographical positions • Imbalances due to globalization, exports, and free trade
Uncertainties	• Uncertainties about future fossil-free fuels and infrastructural changes for their production • Uncertainties about future changes in transport infrastructure • Uncertainty in legislations, regulations, and long-term strategies

Table 4.5 – The five main areas of challenges in making freight sustainable (LSPs' perspective)

4.3 Themes and challenges in making urban freight distribution sustainable

The systematic review of selected articles by running an analytic inductive analysis process led to identification of major themes and challenges in making urban freight distribution sustainable. This section provides a classified synthesis of identified themes and challenges.

4.3.1 Identified themes

Eight major themes emerged during the third research study, namely, juridical and financial regulations/restrictions/limitations; structural and infrastructural; managerial; environmentally friendly modes of transportation; technological developments; emissions and fuels economy; distribution services; educational.

The extract of the grouped themes are illustrated in Table 4.6. For detail explanation of each major theme please refer to the third appended paper.

Juridical and financial regulations/restrictions/ limitations	• Time restrictions-Delivery timing-Vehicle access time restrictions • Vehicle load capacity restrictions-Vehicle access weight/size/capacity restrictions • Environmental zones/Low emission zones/Clear zones • Financial regulations/means
Structural and infrastructural	• Urban Consolidation Centres (UCCs) • Maximizing capacity utilization of existing infrastructures • Underground urban goods distribution
Managerial	• Planning, control, measurement, monitoring, modelling, assessment/evaluation, cooperation/coordination/collaboration, and partnership
Environmentally friendly modes of transportation	• Inter- and co-modality • Developing environmentally friendly vehicles
Technological developments	• Developing clean/green/environmental technologies and ICT
Emissions and fuels economy	• Developing fossil-free fuels with zero emissions with minimal antagonistic effect somewhere else
Distribution services	• Home service distribution/delivering the goods to the customers' home • Neighbourhood drop-off points • Use of packaging automates in the distribution process
Educational	• Increasing sustainability awareness/change of behaviour by investing on research and education

Table 4.6 – The eight major themes in making urban freight distribution sustainable

4.3.2 Identified challenges

In total, seven major categories of challenges in making urban freight distribution sustainable were identified (illustrated in Table 4.7). These categories were: decoupling; restructuring;

costs/financial viability; operationalization; uncertainties; lack of visionary leadership; corporate governance. For detail explanation of each category of challenges please refer to the third appended paper.

Decoupling	• Decupling economic growth from freight distribution and transport growth
Restructuring	• Antagonistic effects of distribution trends on environment and sustainability • Restructuring of urban distribution due to globalization (global- change and chain)
Costs/Financial viability	• Higher average costs of freight distribution in urban areas (short distance) than inter-city (long distance) freight distribution • High set-up and total costs of city logistics initiatives especially in the short term • High investment costs in developing, constructing, or restricting the infrastructure
Operationalization	• Considerable lack of knowledge in understanding what city logistics and its initiatives/themes are • Reluctance of city logistics stakeholders to accept or participate in initiatives • Inefficiencies in urban freight distribution
Uncertainties	• Strategic uncertainties • Operational uncertainties • Uncertainties due to psychological reluctance of customers to buy clean technologies • Uncertainties due to antagonistic effects of city logistics initiatives in urban areas
Lack of visionary leadership	• Vague vision and goals • Short-term market perspectives in focus • Creating a new and novel sustainability urban mobility culture • Inertia and resistance to change
Corporate governance	• Bureaucratic difficulties and administration barriers • Decision making by several actors from municipality and regional to state levels • Variations in policy measures as well as governmental policies and rules in different urban areas • Lack of political commitment • Scarce and out-of-date national and local policy frameworks regarding freight distribution

Table 4.7 – The seven major challenges in making urban freight distribution sustainable

5. DISCUSSION

"We can't solve problems by using the same kind of thinking we used when we created them."
Albert Einstein

This chapter presents the patterns of the themes and challenges identified during the research process as well as a list of recommendations for governance of supply chains from a complexity theory perspective.

5.1 Synthesis of themes in developing sustainable supply chains

Making supply chains sustainable as well as developing them sustainably will never happen by just one activity; instead a packet of sustainability-oriented activities with minimal antagonistic effects on each other is required. In the following, syntheses of patterns of the themes of activities identified during the research studies are explained.

5.1.1 Increasing sustainability awareness

The first step in developing sustainable supply chains is of an epistemological character as it relates to the awareness of supply chain stakeholders. All stakeholders have to gain knowledge and be willing to learn about what sustainable development is and what the thoughts behind it are. In addition, the concept of sustainable development should be translated into the context of supply chains activities, operations, and processes.

Researchers, educators, and media have a great responsibility to reduce this gap of sustainability knowledge especially in global supply chains. Knowledge and awareness are powerful tools to reduce the inertia against treating the environmental and social aspects of the three bottom lines of sustainability as being equal to the economic aspects.

5.1.2 Closing the loop of supply chains

Closing the loop of supply chains by integrating forward and reverse (i.e. downstream and upstream) logistical flows of goods, services, resources, and information is another theme discussed towards attaining sustainability. Closed-loop supply chains call for a systematic and circular rather than linear thinking from cradle to grave as well as grave to cradle. As a result of this thinking, developing completely renewable goods and resources as well as the integration of both forward and reverse logistical services may emerge.

5.1.3 Making supply chains energy-efficient

Increasing the energy efficiency of supply chains has a direct relation to the reduction of GHG emissions. There are several opportunities to make supply chains energy-efficient. Some examples are production of renewable fuels - with minimal antagonistic effects somewhere else - in base industries; technological developments (by investing in innovation, clean technologies like environmentally friendly resources, ICT, etc.); and adopting governing instruments by legislation.

Stelling (2011) summarizes the transport and logistical related green legislation as:

- *Financial:* energy and CO_2 tax on fuels, road toll for heavy vehicles, infrastructure charges on the railway, vehicle license duty/vehicle tax, congestion charging, tax exemption for biofuels, emissions trading/ETS, kilometer tax, marginal tax on CO_2, trading in freight capacity/collective traffic for goods

- *Knowledge-based*: information giving and advising, research and development, demonstration projects, benchmarking and rating, eco-labeling/certification and environmental management, and environmental calculations/footprints
- *Juridical*: fuels classification/regulation, environmental classification of vehicles, vehicle size/length/capacity/weight, environmental zones and restrictions on vehicle circulation/idling and ownership, quotas, and vehicle maintenance control
- *Societal*: infrastructure investments, intelligent transport system/ITS, transport-efficient community planning

Higher utilization of existing resources (by collaboration; by increasing load factors, fill-rates, efficiency; and by optimizing supply chain design) and infrastructure capacity can also contribute to both environmental (by reducing GHG emissions) and economic gains.

5.1.4 Making supply chains environmentally responsible

Although all the above themes of activities are more or less related to making the supply chains environmentally responsible/green, several reviewed articles and interviewees reflected more specifically on the activities, policies, and strategies of doing so. However, greening the logistics and supply chains (environmental sustainability) is closely aligned with economic objectives (economic sustainability) (McKinnon et al., 2010, p. 14-15). Supply chains will become environmentally responsible when:

- the demand sides show a pattern of sustainability (by reducing demand for goods and services, change of consumers' behavior, and restructuring supply chains design)
- the remaining demand is fulfilled from sustainable supplies (like completely renewable goods and resources, corporate socially responsible suppliers)
- the activities/operations, processes, and design of the chains become environmentally sound. This would involve eco-design at all levels of packaging systems (products and primary, secondary, and tertiary packages). It would also involve resources, such as vehicles, unit-load carriers, machineries; increasing utilization of existing resources and infrastructures; eco-deriving/eco-sailing/green take off and approach in transport sector
- a complexity theory perspective is taken into account to understand and learn to deal with antagonistic effects and conflicts of a paradoxical character in developing sustainable supply chains (refer to section 5.2.5).

5.1.5 Managerial issues

Managerial issues can also accelerate transformation of supply chains towards sustainability. Such issues are related to sustainability- assessment/evaluation, benchmarking, measurement, monitoring, modelling, cooperation/coordination/collaboration/ partnership; taking initiatives; creating sustainability culture/value in the supply chains; etc.

Several examples of managerial issues emerged during the research studies such as: *environmental impact assessment* of supply chains- activities (like transport and distribution) and concepts (like centralisation, postponement, e-commerce, and city logistics initiatives); *environmental evaluation* of suppliers; *sustainability measurement and monitoring* by developing internal scorecards and platforms (like GHG calculators developed by LSPs); publishing annual *sustainability reports* and *taking initiatives* (refer to the second appended paper); as well as *cooperation, coordination,* and *collaboration* among the stakeholders (discussed in all appended papers).

5.2 Synthesis of challenges in developing sustainable supply-chains

The complex nature of supply chains has made their transitions towards sustainability targets tremendously challenging. Supply chains are complex socio-technical systems constituted of various heterogeneous and interconnected components/agents. They are also facing constant changes and are influenced by the environmental, economic, and geopolitical contexts in which they operate. The syntheses of the patterns of challenges that were identified in the research process are explained in the following sections.

5.2.1 Change of behavior

The first challenge is to change behavior of supply chains stakeholders. This requires an increased awareness in supply chains stakeholders about what sustainable development is and interpret what its principles [in context of supply chains] are. To *globally* increase sustainability awareness of stakeholders is a further challenge as supply chains are evolving globally both horizontally and vertically.

However, increasing awareness will not necessarily change the behavior of supply chains' stakeholders. There are still resisting or ignoring mindsets against deploying clean technologies (Brown et al., 2007), accepting principles of peak oil (Chapman, 2007), and believing emergence of global village. This has led to high inertia against changing the current business logic of logistics and supply chains where all dimensions of sustainable development are sacrificed for just short-term financial sustainability. In addition, the objectivist, positivistic, reductionist, linear, and short-term thinking existing in logistics and supply chains has led to fear and high resistance to changes in favor of sustainable development principles.

There is also political inertia against changing the politicians' mindsets. Taking just short-term perspectives – to be economically sustainable in the short-term and win the elections – and a fear to change the social structures while dealing with the environmental issues are some exemplary factors contributing to political inertia.

5.2.2 Costs

The issue of costs was put forward in all research studies. Sustainable development, like any type of development, might be initially very costly. For example, it is costly to carry out research on and to develop new infrastructures, clean technologies (like carbon capture and storage (CCS) and distributed electricity production (LETS rapport, 2011)), fossil-free fuels and sources of energy, and environmentally friendly vehicles. It is also costly to redesign the supply chains, change the fleets, find alternatives for non-renewable natural resources, educate the stakeholders, and pay for green/sustainable goods and services.

For the moment it seems that neither producers nor consumers (in greater masses) are willing to pay the costs. Furthermore, there is a circular pattern of different actors and their responsibilities concerning who is going to start or initiate such. It seems far too easy to state that our customers or the government do not care then why we should! This challenge becomes even more troublesome in global markets as well as businesses with low profit margin where free trade and business ethics are clearly ignored.

5.2.3 Implementation

Other factors directly hinder implementation of the principles of sustainable development in operations of supply chains. There are many *uncertainties* regarding the sustainability

consequences of supply chain design and operations. From ecological and social perspectives it is not clear how, for example, the localization of production impacts societies locally or globally. How do logistics structures influence the environment? What are the times perspectives regarding the changes must be made in different supply chains activities?

There are also a number of strategic uncertainties related to government legislations/ regulations and decisions, future changes in logistics infrastructure, commercialization of new clean technologies, consumer behaviour and demands, competitive advantages and strategies formulated by organisations, and the nature of future fossil-free fuels and infrastructural changes for production of such fuels especially in global markets.

In addition, there are a number of operational uncertainties in choice of fuels, the routing of vehicles, and negotiation of contracts. Operational uncertainties may also happen due to unexpected/unforeseen incidents like order cancellation, delivery-time changes, new customers' demands, traffic congestion, road construction, flea markets, natural disasters, weather changes, accidents, mechanical failures, etc.

McKinnon (2010) sheds light on uncertainties and problems with product-level life cycle assessment (LCA) and carbon auditing of supply chains, such as defining boundaries and allocating energy and emissions, different regulations governing carbon labeling, complexity, and time consuming. In addition there is no single, agreed method of measuring the environmental impact of logistical pollution (McKinnon et al., 2010, p. 42). It is also unknown the extent to which companies calculations are independently audited.

Other examples of hinders to the implementation of sustainability principles in the context of supply chains are:

- risk and opportunity costs of losing key partners
- lack of metrics and available data for measuring green practices across a global supply chain (Mollenkopf et al., 2010),
- bounded rationality (incomplete knowledge that people have and use [and misuse] when making decision (Baldwin et al., 2010)
- opportunistic behavior (Nilsson, 2005; van Hoek and Johnson, 2010)
- asymmetric information

Other challenges to the implementation of sustainable freight transport in supply chains discussed in the research studies are border-crossing flows of goods and resources between Sweden and other countries; differences among transportation- infrastructures, governing rules, standards, technologies; and competition.

5.2.4 Corporate governance

Governing sustainable supply chains corporately where all stakeholders accept and follow the business norms and legislations is another challenge. One reason is several contexts in which supply chains operate. This context can change from a local place to urban areas, regions of a country, and different countries. Another reason is the fragmented nature of the supply chains. Each component/agent of the chain may be a part of several other chains, have contracts with various organizations, and be regulated by different rules and laws.

5.2.5 Antagonistic effects and paradoxical conflicts

The antagonistic effects and paradoxes existing in supply chains activities are other challenges. *Carbon leakage/spillovers* and *rebound effects* are some exemplary paradoxical

phenomena. Carbon leakage/spillovers involve the shift of emissions from one sector to another (e.g. from transport to production of electricity) or from one country to another.

Rebound effects occur when reducing environmental degradation from one sector or activity leads to increasing environmental degradation in another. There are many examples of rebound effects in supply chains. One is when energy efficiency or cheap fuel encourages higher consumption and mobility, or e-commerce increases goods transport while decreasing person transport, or growth in Gross National Product (GNP) and trade increase demand for freight transport and distribution (LETS-Rapport, 2011).

Negative loops in supply chains should be considered, as well. For instance, exports and geographical positions may lead to imbalances in both goods and resources flows; and Lean and JIT (Just-In-Time) strategies that employ higher service-levels by small lot sizes and short lead-times may increase less-than-truckload transport and traffic intensity, packaging, and handling services (Mollenkopf et al., 2010). Economic growth may increase mobility; production of biofuels from biomass may lead to deforestation and desertification and increase land- and food prices. Another example is increasing demand for freight transport or what Paxton (1994 cited in McKinnon 2010) calls 'food miles' as a result of wider sourcing of food products.

5.3 Governing transitions from a complexity theory perspective

Governing transition of complex systems, like supply chains, call for a perspective that can grasp their complex characteristics and changes in time.

A complexity theory perspective has been found to be a beneficial perspective for this sake as it comprehends the transformative transition towards 2050 targets (discussed in chapter 1) and take characteristics of supply chains (open, dynamic, nonlinear, paradoxical, and anti-positivistic) and their components and activities into account. A complexity theory perspective also considers this fact that the transition path may not be uniform, deterministic, and entirely controllable for different types of supply chains (Rotmans et al., 2001).

In the following sections, some suggestive lessons for governing transitions of supply chains from a complexity theory perspective (explained in chapter 3) are discussed.

5.3.1 Various heterogeneous components and activities

The first lesson in governing the transitions is to recognize the stakeholders that are influenced by and that influence decision/policy making in supply chains (necessity of a holistic view). However, as recognition of all stakeholders of all tiers of the chains might be counterproductive "*the key is to sort out some basis for determining which members are critical to the success of the company and the supply chain and, thus, should be allocated managerial attention and resources*" (Lambert and Cooper, 2000, p.69).

The second lesson is to increase sustainability awareness/knowledge of stakeholders by, for example, investing in research and education. This will be an important undertaking to change behavior, mindset, culture, as well as to reduce inertia. The willingness, especially political (Räthzel and Uzzell, 2009), for making the supply chains sustainable should also be considered. As Jönson and Tengström (2005, p. 222) elaborate: *"When the political will is lacking, the problems can be recognized, but are not deemed enough – in practice – for there to be a real change in the system in place."*

The third lesson is the importance of persuasion. All the stakeholders should be persuaded by supply chain orchestrators or decision/policy makers about governing legislations and policies in making supply chains sustainable. This may increase the trust among politicians and stakeholders as well as acceptance of new legislations and policies.

The forth lesson is to appreciate the diversity of components and activities instead of too much simplification or reduction. "*Getting a balance is key, as diversity is seen as being hugely advantageous in terms of innovative capabilities if set within a conducive organizational culture*" (Baldwin et al., 2010, p. 702). The art is to govern simultaneous sustainability and transformation (transformative transition) of supply chains at the edge of chaos where optimal diversity/heterogeneity is appreciated. It is clear from the identified themes that supply chains will not become sustainable by just one activity; instead a packet of strategies and activities with minimal antagonistic effects on each other is required.

5.3.2 Nonlinearities

The first lesson is to understand the nonlinear effects of governing rules and policies. Some todays' decisions and actions may have high consequences on future decisions and actions. For example, decision about investment on logistical infrastructure or design of supply chains may have long-term effects on future of supply chains operations. Although study of all nonlinear consequences (effects) of today's sustainability oriented decisions and actions (causes) might be difficult, some tools like scenario analysis and agent-based modeling can be helpful.

The second lesson is to implement rules and policies that may have a larger consequence than others. For example, it is expected that several new technologies needed for greening the (freight) transport, infrastructures, production, and base industry be introduced by 2020 (LETS-Rapport, 2011). After 2020, governing rules and policies should be defined which encourage implementation of those technologies that may have the largest consequence beyond greening (i.e. job creation, safety and security, etc.).

5.3.3 Openness

As supply chains are open systems with continuous flows (mentioned in chapter 3) through them from the entire globe, global governing rules and policies are required. Although tougher national regulations (rules and policies) can be defined, international regulation are also required. For example, introducing GHG emissions taxes or eco-labeling should become global to make the price and trade of products as well as services fare.

5.3.4 Self-organization and emergence

The first lesson from this aspect of complexity theory perspective is to develop the values in supply chains in favor of sustainable development. The governing regulations (rules and policies) should respect interactions among and freedom in components. Thanks to interactions and freedom, innovative sustainability oriented ideas might flourish. As a result, predefined values (in this case sustainable development) can emerge by the self-organization of activities towards sustainability without many strict regulations for sustainable development of each component. However, in reality, the main challenge is to make a balance among the degree of regulations and freedom/openness for self-organization. Similarly, global patterns of corporate social responsibility (such as a global value) can emerge wherever self-organizing economies (which embody the corporate social responsibilities) can be regulated.

Regulations must also encourage the communication and information sharing among the stakeholders.

Another lesson is to decentralize decision/policy making in supply chains. Decentralization can be from a global level to national and regional/local. Due to decentralization, the agents will have the possibility and freedom to self-organize. Decentralization can facilitate bottom-up changes in sustainable development of supply chains.

Supply chains will not become sustainable without a global perspective. Sustainability, in todays' global supply chains is not just a regional or national issue; it is global as well. From the political side it means that all nations of the world, irrespective of political parties or conflicts, must work side by side to tackle global problems like global warming and climate change. From the industrial side, a global perspective is essential, as well. Today, industries can simply change the movement of materials, components, and human resources in supply chains by simply restructuring their global supply chains. Supply chains will transform towards sustainability while global patterns of corporate social responsibility emerge.

5.3.5 Adaptation

The first lesson for future regulations is to increase "*agency*" characteristics of supply chains that can intelligently process and analyze the information and learn from the events (Nilsson, 2005; Abbasi, 2008).

The second lesson is to define simple top-down sustainability oriented schemata of regulations (rules and policies) and norms (juridical, financial, social and knowledge-based regulations (Stelling, 2011)) while letting the bottom-up innovative self-organized and adapted schemata emerge as well. For example, while defining regulation for sustaining freight transport and distribution, the industries/businesses should also have enough flexibility to adapt them with sustainability schemata and requirements of their supply chains.

A third lesson is to consider the different requirements of different industries/businesses in the regulations. In other words, *one shoe does not fit all*: one regulation or standard cannot be suitable for different industries (MacLean, 2010) or markets (McKinnon et al., 2010, p. 141). Supply chains will not become sustainable or develop sustainably by just one strategy or activity. Instead, packets of strategies and activities with minimal antagonistic effects on each other are required! The identified themes in this thesis may be beneficial for design of such packets. However, the packets of strategies and activities may be different for different types of supply chains. Sustainability-oriented strategies and activities should be adaptive for different requirements of different types of industries and supply chains.

The last lesson from this theme is the necessity of a stepwise rationalization of costs in making supply chains sustainable, for example, by subsidies and incentives. This will increase the likelihood of adaptation of top-down schemata.

5.3.6 Co-adaptation and Co-evolution

The regulations must also encourage adaptation of emerging sustainability oriented technologies, norms, and behaviors. Sustainability schemata of supply chains co-adapt and co-evolve with increasingly emerging clean- technologies, services, products, infrastructures, and regulations.

5.4 Further propositions

The results of the research studies led to further propositions in making supply chains and their activities sustainable. The following propositions are some exemplary ones which have potentiality for further investigation.

P1: *In order to make supply chains sustainable, the underlying financially driven logic of supply chains needs to be reassessed in both research and practice, and the other basic tenets treated and prioritised by policy makers and organisations in the same way as costs are today.*

Sustainability should be integrated into supply chain management (SCM) and not be treated as a concept or theory of its own (like sustainable supply chain management, environmental logistics management). This separation, as literature today manifests, identifies sustainability as a factor of its own; an add-on to SCM. Instead, environmental and social issues should be treated in SCM in the same way as revenues and costs are today. Otherwise, sustainability will only be an add-on which will be given lower priority in research, boardrooms, and management teams.

P2: *For the integration of sustainable development into supply chain management to become reality, holistic models and perspectives in which comprehension, not elimination or reduction, of the emergent complexity needs to be explored, developed, and used.*

A complexity theory perspective can contribute to design of such holistic models (refer to chapters 3 and 6). A holistic perspective should be also taken into account while deciding for transportation systems. Decision in freight transportation should not be taken in isolation; instead should be taken by considering decisions about other major activities of supply chains (refer to section 1.4).

Comprehension of complexity in freight transport should be also considered while developing sustainable transport. A dominant pre-assumption in developing sustainable transport is that more environmentally friendly modes should be used. This may be true in the short-term but the standpoint made from our second research study is that it will not solve the problem in the long-term. Transportation should develop resiliently. Resilience means that in case of peak loads, for example, for one mode, the other modes must be ready to be replaced. Peaks can happen due to natural disasters, weather conditions, risk and security reasons, terrorist attacks, etc. In addition, optimal competition among transporters, and modes of transport, may decrease the price of transport service for the customers.

Using low speed modes of transport may also do not be appropriate for all types of supply chains. For example, cold chains or some types of food supply chains require faster transport in their operations. Some interviewees raised another dimension which is related to geographical restrictions or distribution of the resources of the world in a way which is impossible to reach by all modes or can be reaching by just one mode. For example, one interviewee stated: *"There are not so much rail opportunities in Denmark in compare to Sweden and that is mostly related to how its geography looks like".* Another one with core competency in air transport mentioned: "*In north parts of Norway, the only mode of transportation is either by car or the aircraft. So, if we do not fly, then the society there will almost stop".*

P3: *In order to transform sustainability ideas and theories into action, i.e. be operationalized, the difficulties of interpreting the concept of sustainable development and the inertia of change inherit in the majority of supply chains must be made priority issues for decision- and policy makers.*

The three pillars/bottom lines of sustainable development have been defined from macro levels of society and economy (Aras and Crowther, 2009). However, the difficulties of interpretation of all pillars (George, 2007; Byrch et al., 2007) for micro levels of society and economy as well as the emerging complexities of interrelations of all pillars have made the operationalization of sustainable development difficult.

P4: *For sustainable development to be a natural part of future supply chains the mind-sets of people within organisations, supply chains and nations needs to be critical, creative and incorporative of sustainability perspectives and assumptions.*

In supply chains, every single stakeholder becomes responsible for sustainable development of the chain(s). Investment on education (Dale and Newman, 2005; Mason, 2009), innovation, research; as well as visionary leadership are powerful tools for changing the stakeholders' mind-sets and making them corporate socially responsible.

P5: *In making supply chains sustainable, organisations must take advantage of uncertainty by exploring, developing and communicating different business logics, and from these, establish new ethical, environmental, and social programmes and policy measures.*

P6: *For sustainable development to become reality in supply chains it must be shown that development of environmentally and socially friendly strategies and operations will not sacrifice economic growth in the long-term.*

This can be done in two ways:

a) By entering the environmentally and socially responsible (corporate social responsible) operations to the business model. This will happen when the business earns money by offering green and ethical products and services.
b) By showing that although development of environmentally and socially friendly strategies and operations may lead to higher costs, instead the investment will return as a gain or profit in the future.

P7: *Complexity of logistical operations may lead to asymmetric information for measurement of GHG emissions and vice versa.*

At the moment, there are different and often asymmetric methods, models, and perspectives for measuring GHG from logistical operations. For example, some companies work with CO_2 equivalent while others consider each part of GHGs separately. In addition there are tremendous difficulties in precise demarcation of borders as well as allocation of emissions for all logistical operations.

P8: *Sustainable development calls for both 'top-down' and 'bottom-up' changes.*

Both top-down and bottom-up changes can be influential for transition of supply chains activities towards sustainability. The top-down ones may happen by political/governmental incentives (carrots) and legislations (whips). Political willingness and actions are important

factors for tackling the challenges against global environmental protection (Räthzel and Uzzell, 2009) and supply chains sustainable development (Hall and Matos, 2010).

The bottom-up ones may happen by taking initiatives, persuasion of people, adoption of technological innovations (Isaksson et al., 2010), as well as collaboration among local-stakeholders and governments. Proactive bottom-up changes may accelerate the pace of development and facilitate operationalization of sustainable development.

P9: *Sustainable development calls for both 'short-term' and 'long-term' strategies.*

The long-term ones should be followed by researchers, NGOs, and Lobbies. That's the reason that it is said that sustainable development requires sustainable people. Short-term strategies can be more flexible. We may follow semi-sustainable activities for short-term strategies.

6. CLOSING REMARKS

"Anyone who has never made a mistake has never tried anything new."
Albert Einstein

The aim of this chapter is to highlight the concluding remarks of the research as well as suggestion for further research.

6.1 Conclusions

The purpose of this research journey was to explore and classify themes and challenges in developing sustainable supply chains activities in general, and freight transport and urban distribution in particular.

Out of the emerged major themes and challenges (summarized in chapter 4), further syntheses were done which led to identification of five main themes and challenges (discussed in chapter 5) in developing sustainable supply chains. The five synthesized themes were "increasing sustainability awareness"; "closing the loop of supply chains"; "making supply chains energy-efficient"; "making supply chains environmentally responsible"; and "managerial issues". On the other hand, the challenges were related to "change of behavior"; "costs"; "implementation"; "corporate governance"; and "antagonistic effects and paradoxical conflicts". Chapter 5 was continued by further propositions as well as some suggestive lessons for governing transformative transitions of supply chains towards sustainability from a complexity theory perspective.

In the follow, some concluding remarks of the research are highlighted.

The challenges
While there seems to be a growing awareness in society on environmental issues, especially among younger generations, it became clear both in literature and during interviews that *awareness and knowledge* of sustainable development is still low and the operationalization of environmental areas are often met with reluctance. Transition of supply chains towards sustainability becomes a world-class challenge when it comes to increase sustainability awareness of stakeholders globally. This becomes even more challenging as supply chains evolve globally. In addition, there is lack of knowledge about sustainability-oriented strategies and operations/activities in supply chains.

Increasing awareness and knowledge about sustainable development and the thought behind its principles are powerful tools for change of stakeholders' behavior (Allen and Strathern, 2003) as well as reduction of inertia against changing the current business logic of logistics and supply chains.

The challenge of increasing *costs* of developing corporate social responsible (environmentally and socially responsible) activities was raised several times during all the research studies. For example, it is costly to globally educate the stakeholders; do research about and develop-new infrastructures/clean technologies/fossil-free fuels and sources of energy/environmentally friendly vehicles; redesign the supply chains; change the fleets; find alternatives for non-renewable natural resources; and educate the stakeholders. Increasing costs may decelerate the pace of operationalization of sustainable development in supply chains. The challenge of

costs is more troublesome when short-term views for decision making are in focus and the stakeholders are not willing to take initiatives for paying extra for corporate social responsible solutions.

To take short-term perspectives while dealing with transformation of supply chains activities towards sustainability is another challenge. It can also be concluded from both literature and interviews that long-term perspectives are seldom on the agenda. In LSPs, the large actors had 5-7 year visions while the medium sized had 1-3 year views on the future, and even less when it came to environmental and sustainability issues.

A long-term view is essential as, for example, today's decisions about infrastructures, supply chains design, transportation fleets, and business models may have long-term effects on future strategies and operations. To break the current ways of thinking and patterns of behavior is also time-consuming. Although innovation can be radical, adaptation of new technologies as well as change of behavior are just incremental (Rogers, 2003).

A "wait and see" behavior of supply chains stakeholders is another challenge. Taking initiatives to become more environmentally friendly, lowering CO_2, and develop new green solutions are seldom met. The LSPs, for example, have such a "wait and see" mentality as they are waiting for the customers to value the environmental aspects and not only cost and time when purchasing logistics services.

Towards a complexity theory perspective

Supply chains are complex systems which will be even more complex in the future. Increasing population of the world will increase the demand for goods and services in the future. In addition, thanks to information and communication technologies (ICT) as well as feasibility of quick transport of goods and human to every corner of the world, the interactions among the supply chains will increase. These factors will all contribute to increasingly complexity of supply chains in their evolution.

Developing sustainability of complex supply chains is complex, too. Such development call for taking numerous nonlinear interrelated eco-, socio-, geo-, technical- and political decisions about numerous processes, activities, and component of numerous types of supply chains. The consequence of nonlinearity is that even factors consider less important may produce great changes in the system.

The packet of strategies and activities for transition of supply chains towards sustainability can be studied from a complexity theory perspective. This perspective can enable us to:

- Take a more holistic view on whole available strategies and activities and then selecting those which are most appropriate for each type of supply chains
- Analyze antagonistic effects of strategies and activities on each other and recognize conflicts of a paradoxical character existed in supply chains
- Analyze the changes influenced by/influencing the strategies and activities
- Avoid too much simplification of the systems (supply chains); i.e. run them at the edge of chaos where enough diversity and freedom, among the sub-systems, for sake of self-organization is appreciated. This can lead to evolutionary sustainability and innovation if conducted with an appropriate organizational culture
- Design and re-design the transition paths for each type of supply chains. Differences among different industries have led to different- supply chains network structures, services, and logistical flows among them. In addition, supply chains are influenced

by different types of natural and human resources as well as social context in which they operate. Supply chains may even nonlinearly develop vertically and/or horizontally at different stages of time. As a result, the transition path towards sustainability might be different for different supply chains or even for one supply chain in different periods of time.

6.2 Contributions

The ultimate contribution of this thesis is production of a little scientific knowledge for developing sustainable supply chains activities; especially freight transport and urban distribution. Although it is hard to measure everything, the major contributions of this thesis are highlighted in the follow.

Theoretical

The three appended papers as well as synthesis of all identified themes and challenges in developing sustainable supply chains (discussed in chapter 5) are the main theoretical contribution of this thesis. I hope that the readers – by reading this thesis – have a more holistic view on existing themes and challenges which are discussed in making supply chains-, freight transport-, and urban freight distribution environmentally sustainable.

Methodological

The research process explained in chapter 2 is the main methodological contribution of this thesis. I hope that the readers – by reading this chapter – have a better knowledge about how knowledge is scientifically produced. The contribution can be more or less tracked in discussion about- ontological/epistemological/ teleological standpoints in supply chains, cross-sectional design, methods of analysis and synthesis of data, channels for communication of knowledge (valid and reliable research results), and several criteria for judging the research quality.

Governmental

I do believe that knowledge is co-constructed, co-adapted, and co-evolved by applying perspectives and tools of one scientific discipline in another. The discussion in section 5.3 is just an evidence to show that transition of supply chains towards sustainability can be governed by applying perspectives and tools of science of complexity. This may guide the policy- and decision-makers while they design the future strategies and tackle the challenges.
To tackle the challenges, they should be continuously identified. The identified challenges in this thesis such as: “costs”, “low awareness”, “inertia”, and “uncertainties” are huge concerns that deserve political attention and actions.

Managerial

Managing the supply chains is a challenging task (Lambert et al., 1998; Simchi-Levi et al., 2004). Challenging is one of the characteristics of leaders. The identified challenges might be beneficial for managers and leaders while they approach sustainable supply chain management challenges.

Industrial/Practical

The identified themes might be beneficial for increasing absorptive capacity of industries and practitioners while they design innovative strategies for transitions towards sustainability targets. The identified challenges might also be beneficial for reduction of inertia and uncertainties against operationalization of sustainable development in practice.

6.3 Suggestions for further research

As improvement is continuous, the produced knowledge in this thesis has the potentiality to be continuously improved by further research. In the follow, some opportunities for further research are discussed.

1) Freight transport and urban distribution were the main activities of supply chains which were studied during the research studies. One opportunity is to take other main activities of supply chains, like packaging logistics and production/manufacturing, into account. What is required is a more holistic view on packages of activities and strategies for developing sustainable supply chains over time.

2) Sustainable development in this research was demarcated into environmental issues. However, due to the integrated nature of sustainable development, the integration of environmental aspects with economic and social aspects was also taken into account. To investigate social and economic aspects of sustainable supply chains in more details can be another opportunity for future studies. As Matos and Hall (2007) suggest "*the social dimension of sustainable development is emerging as the key challenge in sustainable supply chains, as it may involve a wide range of stakeholders with disparate goals, demands, and opinions that may interpret the same situation differently, what Hall and Vredenburg (2003) call "stakeholder ambiguity*".

3) The main contribution of this research is exploration and classification of challenges in developing sustainable supply chains. A further step is to investigate the opportunities for tackling the challenges.

4) Study of themes and challenges in governing sustainable supply chains can be another opportunity for future research. The pace of development might increase or a real change will happen if political willingness for making the supply chains sustainable be considered.

5) More thorough analysis of application of the complexity theory perspective on developing sustainable supply chains can be also taken into account. Another opportunity is to compare the complexity theory perspective with other perspectives and analyze the results of each of them on developing sustainable supply chains.

6) Another opportunity is to strengthen the results of the research with more empirical studies or methodological mix (triangulation) like: interview with different stakeholders of the supply chains, investigating themes and challenges for different types of supply chains, and case studies. This can also contribute to development of further theories. As Carter and Rogers (2008) discuss, this research area (sustainable supply chains) requires more theories and frameworks.

7) To study the effects of supply chains design and operations on transportation/logistical flows and vice versa is also interesting. As Lumsden (2006) states: *"The design, layout and operations of the transportation are directly affected by the industry's changed production methods and modified production technology".*

8) Designing a longitudinal research can be also interesting in order to study the changes of themes and challenges during the time.

9) The role of innovation in developing sustainable supply chains deserves higher attention. The identified challenges can drive new innovative solutions and strategies in transformative transition of supply chains towards sustainability.

10) Supply chains and their management are mostly discussed from 'micro economic' aspects. The inter-connection of macro economy with the micro economic aspects can be considered as a future study. Such a study can be very interesting when sustainable city logistics/urban freight distribution is discussed. This can also help to operationalization of a control tower on logistical flows and traffic among different cities and even countries.

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Paper I

“Themes and challenges in making supply chains environmentally sustainable”

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THEMES AND CHALLENGES IN MAKING SUPPLY CHAINS ENVIRONMENTALLY SUSTAINABLE

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Abstract

Purpose - The purpose of this article is to explore themes and challenges in making supply chains environmentally sustainable.

Design/methodology/approach - The study began with a systematic review, and content analysis of articles in top-ranking related journals from logistics, transport, sustainability, and environmental areas, and ended with research propositions contributing to the further advancement of supply chain management.

Findings – Our findings illustrate the major themes published in 18 journals concentrating on sustainable supply chains with special focus on environmental issues. From the systematic review five major areas of challenges for supply chain management are derived; costs, complexity, operationalisation, mindset and cultural changes, and uncertainties. From all of these areas synthesising discussions are provided and research propositions suggested. It is concluded that there is a great need for models and frameworks which consider the complexity involved, take holistic perspectives, and challenge the basic assumptions underlying most of the research published (i.e. reductionism, positivism and economic growth).

Research limitations/implications (if applicable) - Sustainability in this article is mainly related to environmental issues. Analysis of complex interactions between environmental, social and economic aspects might provide opportunities for future research.

Practical implications (if applicable) - The results presented in this paper provide a systematic structure for classifying issues related to logistics sustainability; something which will be beneficial for managers and policy-makers when they approach sustainable supply chain management challenges.

Originality/value - This paper provides propositions for research based on the emergent outcome of challenges that can guide researchers, industry, and policy-makers in future sustainability efforts.

Keywords environment, logistics, transport operations, supply chain, sustainability

Paper type Literature review

Introduction

The history of the world reveals a pattern of development in human life. Nonetheless, current industrial growth is increasingly jeopardising the future sustainability of the Earth and its natural resources and environment. To overcome such concerns, humans should take responsibility to develop environmentally friendly activities both efficiently and effectively. Supply chain activities, which are the enablers of today's social life, are fundamental to such responsibilities. Supply chain management (SCM) encompasses *"the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities"* (www.CSCMP.com**,** retrieved May 14 2010). Furthermore, SCM entails *"the integration of key business processes from end-user through original suppliers, that provides products, services, and information that add value for customers and other stakeholders"* (Lambert, 2006, p.2)*, "for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole"* (Mentzer *et al.*, 2001, p.18). Due to worldwide economic growth and globalisation of industries, a trend over recent decades has been global supply chains resulting in increased emphasis placed on long-distance logistics and transport activities. Economic advantages have motivated Western companies to move production, assembly, etc. to countries where wages are lower and regulations less strict than in the West. However, from ecological and social perspectives it is not clear how, for example, the localisation of production impacts on societies; locally or globally? How do logistics structures and the transport of parts and products influence the environment? On what grounds are supply chain decisions made concerning revenue in relation to social and ecological issues? Over what time perspectives must changes to different supply chain activities be made?

While being economically feasible in supply chains, logistics and transport activities have several negative impacts on the environment. Conservation of resources (like energy, materials, etc), pollution, emissions, noise, congestion and waste disposal are just some negative impacts worth mentioning (World Business Council for Sustainable Development, 2004). Logistics and transport activities are some of the main sources of emissions of greenhouse gases, mostly CO_2. In addition, the transport sector represents the fastest-growing source of greenhouse gas emissions (Brown, 2005).

As a consequence of global supply chains, freight transport is expected to grow from approximately 15 trillion ton-kilometres in 2000 to around 45 trillion ton-kilometres in 2050. In a business-as-usual scenario, the result of this growth is going to be an increase in CO_2 emissions in the same period and for both passenger and freight transport, from 6 gigaton to more than 14 gigaton (World Business Council for Sustainable Development, 2004).

What is obvious at the moment is the necessity of urgent action involving both corporate and inter-corporate (i.e. SCM) responsibility for the mitigation of the negative environmental effects of logistics and transport activities. However, perspectives, solutions and strategies which lead to such mitigation are vague (van Hoek, 1999), especially when it comes to solutions which emphasise the holistic perspective of supply chains or industries. The holistic perspective is especially important when sustainability issues are addressed since *"in the long run there can be no such thing as '80% sustainable'"* (Haake and Seuring, 2009, p.284). As a result, even if several partners or parts of a supply chain are sustainable, the whole is still unsustainable and more work needs to be done. Nonetheless, one important step, a contribution to the supply chain management field, consists of finding, analysing and synthesising the perspectives, solutions and strategies which are currently reported.

Consequently, the authors' standpoint is that the exploration of difficulties, barriers and challenges, as well as learning from the past, will contribute to the emergence and adaptation of new remedies and solutions to handle sustainability issues.
This leads to two research questions being set for this paper:

- RQ1: What sustainability themes have been studied in relevant literature related to supply chains, especially concerning logistics and transport?
- RQ2: What are the main challenges, identified in previous research, in making supply chains environmentally sustainable?

The purpose of this paper is thus to explore the themes and challenges in making supply chains environmentally sustainable and to suggest propositions for further development of supply chain management theory and practice. In this paper we therefore investigate the central aspects of supply chain management and its alignment and integration with sustainability in general, and environmental aspects more specifically.

In the next section, a brief frame of reference is provided to introduce sustainable development and its connection to supply chains and SCM. From this follows the method. The research is mainly based on a systematic review and content analysis of a sample of related journal articles. Emergent themes are thereafter presented, followed by challenges identified from which research propositions are drawn. The paper then ends with concluding remarks and the limitations of the research.

Frame of reference

The concept of 'sustainable development' first appeared in the 1970s and was widely used among professionals in environment and development circles (Björklund, 2005). Despite the current widespread attention paid to the concept internationally, there is no universal definition (Björklund, 2005; Pihl, 1997; Pezzy, 1992). However, the most popular and widely known definition is that of the Brundtland report which is a United Nations-sponsored report: "*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (World Commission on Environment and Development, 1987). Following the United Nations 2005 World Summit, sustainable development encompasses the interdependent and mutually reinforcing pillars of economic development, social development and environmental protection.

Principles of sustainable development have been widely debated in the context of logistics and supply chains (Carter and Rogers, 2008) and concepts such as sustainable supply chain management (Carter and Rogers, 2008; Svensson, 2007), corporate social responsibility (Keating *et al.*, 2008; Dyllick and Hockerts, 2002), green purchasing (Min and Galle, 1997), reverse logistics (Zikmund and Stanton, 1971), and environmental logistics (Wu and Dunn, 1995)) have been presented in research for some time. Abukhader and Jönson's (2004) review of environmentally related journals claims that the concept of 'greening supply chains' has been one of the main themes of discussion in several articles. The authors explain: *"green supply chain is mainly discussion about assessment of the impact of environment on logistics. It evolves discussion of how implementing environmental measures would influence, negatively or positively, the logistics/supply chain infrastructure, and how we can find win-win solutions so that we satisfy the government regulations, satisfy the end customers and stay cost-effective* (Abukhader and Jönson, 2004, p.143). Recently, sustainability has been widened in supply chain literature. Carter and Rogers (2008, p.368) define sustainable supply chain management as *"the strategic, transparent integration and achievement of an*

organization's social, environmental, and economic goals in the systemic coordination of key inter-organizational business processes for improving the long-term economic performance of the individual company and its supply chains." Klassen and Johnson (2004) define 'green supply chain management' as the alignment and integration of environmental management within supply chain management, and, as stated by Seuring and Müller (2008, p.1629) *"sustainable business practices have become a prerequisite for suppliers (entrepreneurs) within global supply chains".* Consequently, while the main focus of this article is on environmental aspects of sustainability, due to the integrated nature of sustainable development, the integration of environmental issues with economic and social concerns, have also been considered.

Based on an initial literature review, concepts such as 'environmentally sustainable' logistics, 'environmentally friendly/sound/ preferable' logistics, and 'green' logistics were found to be widely used synonymously (see Ping, 2009; Chunguang *et al.*, 2008). Ping (2009, p.340) states that **"***modern green logistics management is based on the theory of sustainable development, which formed the relationship of promotion and constraint between logistics and the environment"*. According to Björklund (2005), the definition of an environmentally friendly/sound activity can be anything from choosing a more environmentally friendly/sound technique to choosing an activity which is friendly/sound to the environment (i.e. has no negative effect on the environment). In this paper, we have chosen the concept of 'environmentally sustainable' as the denominating term.

Research methodology

This paper is based on a systematic review and a content analysis and synthesis of relevant literature. It takes an interpretive form of synthesising chosen literature (Rousseau *et al.*, 2008) as the goal is to provide propositions and tentative theoretical constructs of themes and challenges found in relevant literature. While there have been other recent literature reviews on sustainable supply chains (e.g. Carter and Rogers, 2008; Seuring and Müller, 2008; Srivastava, 2007) this research provides a modest, but important, contribution by providing propositions for research based on the emergent outcome of themes and challenges derived from the scope of literature reviewed. The paper by Seuring and Müller (2008) is closest in some aspects to this paper. It reports on a literature review on sustainability and supply chain management based on a content analysis, and provides a conceptual framework for the research field. However, while their focus is on the focal company of supply chains (barriers, risk minimisation and product strategies) this paper looks at themes and challenges for both policy-makers and supply chain actors. Srivastava (2007) limits the review to environmental aspects and reverse logistics. The paper by Carter and Rogers (2008) sets out to define and apply sustainability to supply chain management and concludes with a definition and framework for sustainable supply chain management. Their literature review focuses on definitions of sustainability in the logistics and supply chain management context. The Carter and Rogers paper has been a useful starting point for this paper as we have used the results to develop our reasoning and results.

Literature review

This article was initiated by a narrative literature review (Bryman and Bell, 2007). Sources of literature were mainly selected from secondary sources (e.g. books, theses and the Internet) and documents (mainly public documents, company documents and mass media items). The purpose of exploring the existing literature was to be familiar with the following: what is already known about the research area (sustainability, supply chain management, logistics);

main concepts, theories and themes of this area; and finally, significant controversies and unanswered research questions. Consequently, the initial literature review formed the basis for the research at hand. The research was then focused on the research questions with content analysis as main method used.

Content analysis

Content analysis is a set of research tools for the scientific study of written communications with the objective of determining key ideas and themes contained within them (Cullinane and Toy, 2000). Content analysis can be both qualitative and quantitative, where the latter seeks *"to quantify content in terms of predetermined categories and in a systematic and replicable manner"* (Bryman and Bell, 2007, p.302). Qualitative content analysis can satisfy the inductive assumptions of qualitative researchers. Qualitative content analysis comprises an exploration of underlying themes in the materials being analysed. The aim is to be systematic and analytical but not rigid. Content analysis is often initially guided by some pre-set categories, in this case the three pillars of sustainable development and three levels of supply chain activities. However, other methods of data analysis should be allowed as they provide more value to the final result. With qualitative content analysis there is much more movement back and forth between conceptualisation, data collection, analysis and interpretation than is the case with quantitative content analysis (Bryman and Bell, 2007). The process we have used for content analysis in this paper is based on a qualitative one, as the area of investigation is complex and is based on a variety of examples, cases, methods, perspectives, etc. The major steps in the content analysis are now described.

Research questions

Based on the initial literature review, and together with several discussions with industry representatives and researchers working within SCM and/or sustainable development, the research questions were set (Cullinane and Toy, 2000; Bryman and Bell, 2007). Due to the complexity involved in sustainable development, i.e. it encompasses social, economic and environmental aspects, and covers the global setting of humans, organisations and societies, it was challenging to set the scope of the research. While the focus of the paper had been set on environmental aspects, with special emphasis on logistics and transport issues in supply chains, it is *by definition* impossible to exclude the other basic tenets of sustainable development. Consequently, the research questions are formulated with the goal of encompassing sustainability in SCM holistically rather than being focused on a specific area or industry for analysis. The main perspective is thus set to be from a supply chain management view.

Selection of a sample

In order to answer the research question, a relevant and valid sample of literature and/or documents should be selected (Bryman and Bell, 2007). The sampling method in this paper was based on convenience and non-probability. The selection of convenience sampling is not only to obtain a reliable and relevant base of articles but also due to their availability and accessibility (other types of sampling are snowball and quota). In the first step, the *Electronic Library Information Navigator@Lund* (*ELIN*) was selected as database of population of journals. *ELIN* is an online database at the library of Lund University in Sweden. It includes sources such as electronic journals, E-print archives, JSTOR, IEE/IEEE standards and proceedings, Ebsco fulltext databases, Proquest ABI database.

The research questions call for sampling two types of journals: those related to supply chain management (Type one) and those related to environmental sustainability (Type two). In order to narrow down the amount of journals, relevant keywords were chosen. Journals of type one were restricted to those which contain one or some of the following keywords: 'Supply chain', 'Logistic-', 'Transport', and 'Transportation'. Here, we choose to use both transport and transportation due to their English language differences (e.g. US and UK) while logistic- became a hyphenated link to related terms. Selected keywords for journals type two were: 'Sustainability', 'Sustainable', 'Environment', 'Environmental', and 'Green'. Table 1 presents the total number of journals found of both types.

Table 1. Population of journals types one and two

Journal types	Searching keyword	Number of journals at ELIN@Lund	Total
Journals type one	Supply chain	7	142
	Logistic-	31	
	Transport	66	
	Transportation	38	
Journals type two	Sustainability	13	564
	Sustainable	28	
	Environment	166	
	Environmental	338	
	Green	19	

The next step was the selection of a sample from the number of journals of both types. This selection was carried out through a ranking process. Two criteria were considered to rank the journals: *citations* and *impact factors*. Journals with the highest citation number were selected through the website www.**journal-ranking.com**, while those with the highest impact factor were chosen based on the website www.**isiwebofknowledge.com**. The result was that six journals of type one and twelve journals of type two were selected based on the highest number of citations and impact factors. The journals of type two were then formed into type two A and type two B as half of the journals focus on the environment and the other half on sustainability (see Table 2).

Unit of analysis

The recording unit is the smallest body of text in which an example of one of the content categories (see next section) appears (Cullinane and Toy, 2000). According to Bryman and Bell (2007), decisions about what should be counted in the course of a content analysis are bound to be profoundly affected by the nature of the research questions under consideration. *'Relevant article'* was considered as the unit of analysis in this research. The reason for this selection was to analyse how relevant articles in the journals selected deal with environmentally sustainable/friendly/sound/preferable supply chains. Such articles were chosen according to the following procedure:

A) Initially, based on the initial literature review concepts related to the research area were used to identify suitable articles in both types of journals. Articles in type one journals selected were refined and recorded in a database. They had to include one or more of the following words in the title, keyword, or abstract: 'Sustainability', 'Sustainable', 'Environment', 'Environmental' and 'Green'. For type two journals 'supply chain';

'Logistic- or Logistic*', and 'Transport-' were the keywords chosen for the search. The sample included published articles dating from the first issue of each journal until end of 2009.

Table 2. Journals selected with the highest number of citations and impact factors

Journal types	Journals selected with the highest number of citations and impact factors	Total
Journals type one	*International Journal of Physical Distribution and Logistics Management*	6
	Journal of Business Logistics	
	International Journal of Logistics Management	
	Supply Chain Management: An International Journal	
	Transport Reviews	
	Transportation Science	
Journals type two A	*Critical Reviews in Environmental Science and Technology*	*6*
	Environmental Science & Technology	
	Journal of Environmental Economics and Management	
	Global Environmental Change	
	Environmental Management	
	Journal of Environmental Engineering	
Journals type two B	*Environment, Development and Sustainability*	*6*
	Sustainability	
	Sustainability: Science, Practice, &Policy	
	International Journal of Sustainable Development & World Ecology	
	Journal of Sustainable Development	
	Sustainable Development	

B) The refined number of articles were analysed and ranked by the authors working individually. Both authors were responsible for reading an abstract of each article and ranking its relevance to the research question by colour coding it into the following; relevant (green), semi-relevant (yellow) or not relevant (red).

C) Finally, results of analyses by both authors were compared and further discussions were held out to select the most relevant articles (Tables 3, 4, 5).

In total, the review resulted in 190 relevant articles out of the total sample of 3637, i.e. 5.2%. However, 2407 of the suitable articles are from Environmental Science and Technology. Excluding these, the percentage of selected articles is 11%.

Table 3. Total number of relevant articles and total number of those selected – Journals and articles type one

	Number of suitable articles (Total number of those selected)				
Journal articles selected type one (837 (90))	***Sustainability***	***Sustainable***	***Environment***	***Environmental***	***Green***
International Journal of Physical Distribution & Logistics Management (253 (25))	6 (2)	7 (0)	166 (14)	66 (9)	8 (0)
Journal of Business Logistics (117 (8))	0 (0)	4 (0)	70 (4)	39 (4)	4 (0)
International Journal of Logistics Management (145 (9))	7 (1)	13 (0)	94 (2)	30 (6)	1 (0)
Supply Chain Management: An International Journal (182 (21))	12 (6)	22 (4)	70 (4)	47 (7)	31 (0)
Transport Reviews (111 (26))	6 (2)	39 (15)	24 (2)	41 (7)	1 (0)
Transportation Science (29 (1))	1 (0)	0 (0)	19 (0)	4 (1)	5 (0)

Table 4. Total number of relevant articles and total number of those selected – Journals and articles type two A

	Number of suitable articles (Total number of those selected)		
Journal articles selected type two A (2719 (62))	***Supply chain***	***Logistic-***	***Transport-***
Critical Reviews in Environmental Science and Technology (3 (0))	0 (0)	0 (0)	3 (0)
Environmental Science & Technology (2407 (49))	16 (12)	24 (1)	2367 (36)
Journal of Environmental Economics and Management (20 (2))	0 (0)	5(0)	15 (2)
Global Environmental Change (14 (6))	0 (0)	0 (0)	14 (6)
Environmental Management (100 (4))	4 (3)	26 (0)	70 (1)
Journal of Environmental Engineering (175 (1))	0 (0)	1 (1)	174 (0)

Table 5. Total number of relevant articles and total number of those selected – Journals and articles type two B

	Number of suitable articles (Total number of those selected)		
Journal articles selected type two B (81 (38))	***Supply chain***	***Logistic-***	***Transport-***
Environment, Development and Sustainability (18 (10))	0 (0)	4 (0)	14 (10)
Sustainability (10 (4))	5 (3)	0 (0)	5 (1)
Sustainability: Science, Practice, & Policy (2 (1))	0 (0)	0 (0)	2 (1)
International Journal of Sustainable Development & World Ecology (12 (7))	1 (1)	0 (0)	11 (6)
Journal of Sustainable Development (9 (3))	2 (1)	3 (0)	4 (2)
Sustainable Development (30 (13))	14 (5)	0 (0)	16 (8)

Coding

Coding is a crucial stage in the process of performing content analysis. There are two main elements to a content analysis coding scheme: designing a coding schedule and designing a coding manual. The ***coding schedule*** is a form into which all the data relating to an item being coded are entered. The ***coding manual***, sometimes referred to as the content analysis dictionary, is a set of instructions to coders which specifies the categories used to classify the text. It is based on a set of written rules which define how the text is classified (Bryman and Bell, 2007). Categories need to be devised to provide the basis for classifying textual content (Cullinane and Toy, 2000). The coding manual in this qualitative content analysis is both deductive and inductive.

Initially, two categories were determined in advance: level of discussion in the supply chain, and treatment of sustainability (see Table 6). In the qualitative analysis of themes the sub-categories were created inductively and were driven by the question of which themes and challenges have been put forward and how these have been discussed (Table 6). In this analysis the set of articles was broken down and grouped together based on themes found, e.g. sustainable procurement, green transport policies. The criterion for a theme was that it should either be treated in several articles in similar ways, e.g. “reverse logistics” or be of a thematic character, e.g. “management issues”. While the themes could be separated out and related to specific articles, the challenges identified were of a much more integrative nature, i.e. the issue of cost was raised directly or indirectly in almost every article, as were the issues of mindset and culture. As a result, instead of breaking down the challenges in an analytical manner the challenges were deduced through a synthesis of all articles.

For this synthesis to take place, the authors were inspired by the inductive reasoning suggested by Glaser and Strauss (1967) in the analysis of data. While Glaser and Strauss (1967) propose the reasoning for analyzing empirical data, we also found the reasoning useful for inductive analysis of literature. Practically, this meant that the authors, after reading all the articles and performing the content analysis, used a workshop setup to elaborate on the challenges found, trying to relate these to each other and finally, after several steps of emergent coding, identified five main areas of challenges.

The first coding step involved challenges which were explicitly stated in the articles. Most of the challenges found were directly linked to the phenomenon studied in each paper, e.g. knowing if bio-fuel would become the dominating source of energy for transport or the role of logistics service providers in sustainable urban transport. The second step focused on the conclusions, discussions, future research and limitations of the articles from which implicit challenges could be found in comparison between articles. A third step focused on how issues and challenges had been treated and discussed, i.e. methods and approaches used, type of underlying research (e.g. conceptual, empirical or analytical) as well as main supply chain aspects considered (collaboration, transport, purchasing, etc.). In total this led to a great number of correlated issues and challenges which, after a fourth synthesising step, ended up as five areas of challenges.

Table 6. Coding schedule and manual

Category	Features to be considered (deductively)	Emergent features (inductively)
Level of discussion in supply chain	• Supply/demand/value chain /network – organisation and management • Logistics processes and activities • Transport focus	What themes and challenges have been discussed?
Treatment of sustainability	• Environmental focus • Sustainable development focus (interaction of basic tenets or new dimensions)	How have the themes and challenges been discussed?

Evaluation of quality of content analysis

Based on a review of definitions of content analysis, Bryman and Bell (2007) expose two qualities of this methodology: objectivity and being systematic. Objectivity in this sense resides in the fact that there is transparency in the procedures for assigning raw material to categories so that the analyst's personal biases intrude as little as possible in the process. The quality of being systematic means that application of rules is done in a consistent manner so that bias is again suppressed. As a result of these two qualities, anyone could employ the rules set and come up with similar results. In this research we have tried to be as transparent as possible with the journals selected, the articles analysed and the coding scheme used. Furthermore, the analyses have primarily been carried out by two sets of researchers (Seuring and Müller, 2008; Guthrie *et al.*, 2004) but other researchers were also involved in the discussions to increase the validity of the results (Seuring and Müller, 2008). In line with Spens and Kovács' (2006) suggestions for abductive reasoning we have fine-tuned our categories during the analysis and synthesis processes in order to generate as valuable contributions as possible. At the same time as we have tried to generate exhaustive and mutually exclusive categories (Cullinane and Toy, 2000). While we have been consistent with the research quality recommendations discussed here there are some limitations which need to be highlighted. While the content analysis, especially the quantitative part, is quite easy to follow and reproduce, the qualitative, inductive analysis and synthesis of the 190 articles

being reviewed is of a more complex character as it relates to our previous levels of knowledge and experience. In order to mitigate this issue, the emergent outcomes have been presented at conferences involving both logistics/SCM experts and environmental/sustainability ones from both academia and industry. Furthermore, our choice of journals also influences the results. Studies which are either more focused or of a wider scope, might result in either greater depth of some issues (e.g. procurement) or new factors found in different sources (e.g. decision science, behavioural science).

Findings from the content analysis

The goal of deductive content analysis was to find the number of articles in each category of coding manual. The results (Table 7) show levels of discussion in the supply chain (supply chain management as a whole, logistical processes and activities, and purely transport-focused) as well as treatment of sustainability (environmental focus and sustainable development). For the sustainable development category at least two of the basic tenets of sustainable development should be treated explicitly in the articles. In Table 7, the first number in each square represents the number of articles of type one and the second number refers to articles from type two journals. As the numbers show, there are many articles in both type one and type two with a mainly environmental focus. However, the articles of type two either focus on supply chains as a whole or on transport activities. Logistics is seldom raised as a concept in type two journals (1 environmental and 3 sustainable development) but is treated quite extensively in the literature of type one when environmental issues are addressed (31 environmental). Sustainable development is treated less, especially in relation to logistics in both types of journals (4 in type one and 3 in type two).

Table 7. Number of articles in each category of coding manual (type one + type two)

	Supply chain	**Logistics**	**Transport**
Environmental (61+59)	18 + 30	31 + 1	12 + 28
Sustainable development (28+42)	8 + 24	4 + 3	16 + 15

Themes of articles

In the next step, inductive content analysis was run to explore themes. The themes identified in accordance to the preset matrix of categories are presented in Table 8.

Table 8. Major themes with an environmental and sustainable development focus in literature analysed

		Level of discussion in supply chain		
		Supply chain	*Logistics*	*Transport*
Treatment of sustainability	*Environmental*	• Supply chain environmental management (a) • Green supply chains (b) • Closed-loop supply chains (c)	• Logistics environmental management (a) • Green packaging/purchasing (b) • Green logistics policies and strategies (b) • Reverse logistics (c)	• Transport environmental management (a) • Green transport policies (b) • Transport fuel/energy/ emissions (e)

	Sustainable development	• Closed-loop supply chain orientation (c) • Aspects/concept of sustainable supply chain (d) • Sustainable food supply chain (d)	• Sustainable procurement (b) • Sustainable product recovery (c)	• Transport sustainability management (a) • Sustainable transport policies (b) • Sustainable urban transport (b)

The systematic review of the articles and identified themes led to a synthesis in which the themes could be grouped together, e.g. those with a management focus (Supply chain environmental management, Logistics environmental management, Transport environmental management, Transport sustainability management), etc. The criterion for a theme was that it should either be treated in several articles in similar ways, e.g. "reverse logistics", or be of a thematic character, e.g. "management issues". As a result, five major themes emerged: a) Management issues; b) Green activities, policies and strategies; c) Reverse logistics/closed-loop supply chains; d) Concept of sustainable supply chains; and finally e) Transport fuel, energy and emissions. The grouped themes are illustrated in Table 9.

Table 9. The five major themes derived from grouping of sub-themes found in the content analysis

Management issues	Supply chain environmental management (a) Logistics environmental management (a) Transport environmental management (a) Transport sustainability management (a)
Green activities, policies and strategies	Green supply chains (b) Green packaging/ purchasing (b) Green logistics policies and strategies (b) Green transport policies (b) Sustainable procurement (b) Sustainable transport policies (b) Sustainable urban transport (b)
Reverse logistics/close-loop SC	Closed-loop supply chains (c) Reverse logistics (c) Closed-loop supply chain orientation (c) Sustainable product recovery (c)
Concept of sustainable SC	Aspects/concept of sustainable supply chain (d) Sustainable food supply chain (d)
Transport fuel, energy and emissions	Transport fuel/energy/ emissions (e)

Management issues

Plenty of articles deal with managerial issues of environmentally sustainable supply chains such as assessment, measurement, monitoring, analysis, evaluation of environmental and sustainable activities. Impact *assessment* of supply chain activities is one of these management activities which have been covered in several dimensions, i.e. focusing on transport, e.g. noise, air pollution, congestion, aesthetics, safety (Nicolas, 2000; Jonsson and Johansson, 2006), specific concepts, e.g. postponement (Yang *et al.*, 2005), e-commerce (Sarkis *et al.*, 2004), virtual logistics (Clarke, 1998), vehicle distribution (Holweg and Miemczyk, 2002); logistics structure decisions (Aronsson and Huge Brodin, 2006); biomass fuel supply (Allen *et al.*, 1998); or more holistic aspects of supply chains. Wu and Dunn (1995) take a holistic view to value chain activities from raw material acquisition and inbound logistics to marketing and after-sale services, and McIntyre *et al.*, (1998 a) life cycle impact analysis (LCA) of products or services. Environmental *measurement* and *monitoring* are other managerial aspects which can be found in McIntyre *et al.* (1998 b), Bickel *et al.* (2006), and

Janic (2006), respectively. *Analyses* of roles of information and communication technology (ICT) in sustainable transport (Janelle and Gillespie, 2004) as well as environmental *evaluations* of suppliers (Enarsson, 1998) also deal with management of environmentally sustainable supply chains.

Green activities, policies, and strategies

Green supply chains deal mainly with activities, policies and strategies which aim to make supply chains environmentally sustainable. Treatment of green supply chains in the articles reviewed can be summarised as follow:

- Construction of the concept of green supply chains as well as explanation of trends found in the area of green supply chains and their development (van Hoek, 1999; Skjoett-Larsen, 2000; Cheng *et al.*, 2008).
- Green activities and processes of green supply chains with a predominant focus on packaging (Prendergast and Pitt, 1996; Gray and Guthrie, 1990; Mollenkopf *et al.*, 2005; Garcia-Arca and Prado, 2008), purchasing (Green *et al.*, 1998; Murray, 2000; Murphy and Herberling, 1994), supply and manufacturing (Simpson and Power, 2005), and sustainable procurement (Walker and Brammer, 2009; Preuss, 2009).

What is obvious from analysis of green supply chain-related articles is the predominance of upstream activities. Studies of green downstream activities and concepts such as consumer demand and behaviour, distribution, etc are lacking in the relevant literature.

- Strategies and policies for management or development of green supply chains with a predominant focus on transport policies. Murphy *et al.* (1995), and Murphy and Richard (2003) are the only researchers who shed specific light on logistical strategies and policies. Focus of policies for green/sustainable transport are mainly on urban (Bratzel, 1999; Pucher *et al.*, 2007; Banister, 2000), local (Haywood, 2002), national (Schade and Schade, 2005; Pucher *et al.*, 2007), or continental (Rodenburg *et al.*, 2002; Banister, 2000). Himanen *et al.* (2004), as well as Wittneben *et al.* (2009) discuss the characteristics of environmental policies and conclude that they must be integrated and adaptive.

Analysis of policy-related articles reveals that transport has been the main focus for policy making. However, Himanen *et al.* (2004) truly emphasise that policies for sustainable freight transport have been paid much less attention than policies for passenger transport have.

Furthermore, scenario building and analysis are the most popular tools for study and analysis of policies in such articles. However, scenarios are mainly from a macro (national or continental) perspective. What is lacking is the following; construction, analysis, and planning of scenarios from a micro (local, regional or industrial) perspective. Policy-related articles also reveal that policies and strategies for sustainable development of supply chains are mainly studied in isolation as policies for transport. No consideration is given to other policies which may interact with transport policies. All-encompassing holistic, systematic and evolutionary policy making for supply chain sustainable development is needed.

Reverse logistics/Closed-loop supply chains

Reverse logistics deals with products, processes and resources which flow in opposition to the normal stream in supply chains; namely, from downstream to upstream. Closed-loop supply chains aim to integrate reverse logistical activities and processes with forward ones. Reverse logistics/Closed-loop supply chains in articles analysed have been treated in the following ways:

- Analysis of one or some aspect(s) of reverse logistics like disposition (Daugherty *et al.*, 2001; Skinner *et al.*, 2008; Chandrashekar and Doudless, 1996), product returns (Srivastava and Srivastava, 2006), repair services (Blumberg, 1999), collection strategy (Hanafi *et al.*, 2008), remanufacturing, and product recovery (Inderfurth, 2005).
- Conceptual development of closed-loop supply chains (Clendenin, 1997; Defee *et al.*, 2009).

Study of those articles related to reverse logistics and closed-loop supply chains reveals that environmental concern has been the major focus. Such articles mostly deal with the environmental aspects of sustainability. What is missing is an analysis of reverse logistics or closed-loop supply chain from a sustainable development perspective.

Another missing point is the connection of closed-loop supply chain activities to greenhouse gas (GHG) emissions. A paradoxical concern in supply chains is the reduction of GHG emissions from reverse logistics activities. Closing the loop of supply chains by efficient co-ordination, collaboration and adaptation of reverse and forward flows can bring opportunities for reduction of emissions.

Concept of sustainable supply chains

The main goal of articles of this category is to embody the three bottom lines of sustainable development in the context of supply chains. In this regard, the discussion covers something wider than just an environmentally sustainable supply chain.

A common issue raised in several articles is that research on sustainable supply chains and its management suffers from insufficient theories, models and frameworks. A few articles such as those written by Carter and Rogers (2008), and Markley and Davis (2007) present novel concepts or theories regarding sustainable supply chains. The major purpose of these articles is to bring up some other aspects than just environment, society and economics which may be related to the long-term management of sustainable supply chains. Svensson (2007) emphasises the necessity of having a broad view of all aspects of sustainable supply chain management. Other articles of this category aim to study aspects and concepts of sustainable supply chains in a specific industry with a predominant focus on sustainable food supply chains (Vasileiou and Morris, 2006; Seuring, 2008).

Transport fuel/ energy/ emissions

The last groups of articles deal mainly with transport fuel and energy use as well as transport emissions. In general, the focus is on emissions. Even those articles which analyse transport fuel and energy usage look for opportunities for reduction of emissions. In the following section, a summary of treatment of transport emissions in selected articles is mentioned:

- Some articles discuss opportunities for reduction of emissions as a result of fuel efficiency in road freight transport (McKinnon *et al.*, 1993), efficient energy usage of land transport modes, etc;
- Particle emissions from vehicles (Johnson and Ferreira, 2001);
- Tradable greenhouse emission permits in the transport sector (Dobes, 1999).

The first conclusion from study of this category of articles is that transport emissions are mainly related to vehicles' fuel or energy usage. Even opportunities for reduction of emissions are mainly related to vehicle efficiency and less fuel or energy consumption.

What we have found is missing is the calculation, measurement or analysis of emissions from transport fuel or energy production. In fact, a broader view of transport-related emissions is

required. Secondly, the articles suffer from empirical evidence. The solutions and conservation measures suggested have been mostly brainstormed without being tested, proven or examined in any empirical settings. Thirdly, micro-aspects of transport emissions are usually neglected. For example, packaging can be a main source of reduction of emissions in freight transport, but it is usually neglected in such articles. Efficient packaging design, shape, material and weight, etc. can contribute tremendously to reduction of emissions, especially in the case of mass transport of freights.

Identified challenges for supply chain management

Transforming supply chain processes and activities toward sustainable operations call for identification and analysis of barriers, difficulties and challenges. From our systematic review and content analysis, a number of challenges for supply chain management emerged during the process of synthesising the content of the reviewed literature. While several specific and detailed challenges were raised the synthesis resulted in five main categories of SCM challenges as depicted in Figure 1.

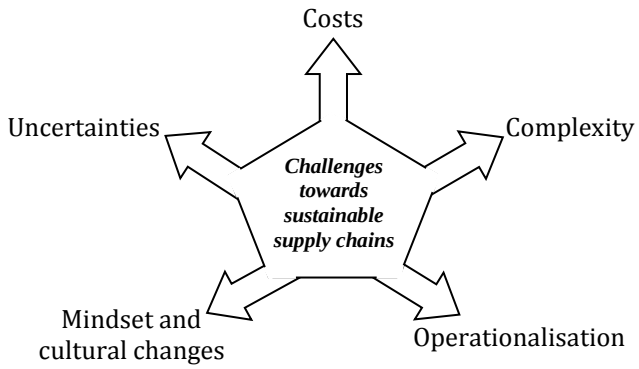

Figure 1. The five main areas of challenges facing sustainable supply chains

Costs

The most frequently highlighted challenge of sustainable development in supply chains is cost. There is certainly a dilemma between reducing environmental impact of business activities and increasing financial cost (McIntyre *et al.*, 1998b). The majority of articles put forward the notion that it must pay to be green. The issue of cost is raised in most SCM areas. In procurement, for example, (Wu and Dunn, 1995; Walker and Brammer, 2009; Simpson and Power, 2005) the dilemma of buying from low-cost vendors and the difficulties of incorporating environmental aspects in purchasing criteria are examined. In transport (Murphy *et al.*, 1995; Bickel *et al.*, 2006) difficulties in quantifying environmental costs are raised as are the high costs of environmental compliance. Welford *et al.* (2003) focus on economic growth and free trade from a sustainability perspective and question the causal relationship of economic growth and welfare which seems to be a fundamental assumption in global supply chains. Gray and Guthrie (1990) put forward the question that: *"In the business of packaging the dilemma is, should a company pursue profit regardless, or pursue an environmentally responsible track at the cost of profit?"* In conclusion, we find that while corporate social responsibility and environmental concerns are regarded as very important for the future of SCM, the issue of cost is still predominant, i.e. costs and revenues are the main drivers in the development of supply chains. This is troublesome since the complexity and uncertainty in new concepts and models better aligned to a sustainable future might be very financially costly, at least initially, and therefore need other basic tenets than cost to be measured upon. The first research proposition is therefore:

P1: In order to make supply chains sustainable, the underlying financially driven logic of supply chains needs to be reassessed in both research and practice, and the other basic tenets treated and prioritised by policy makers and organisations in the same way as costs are today.

Complexity

Dealing with increased complexity due to sustainable development issues in supply chains is another challenge raised by many researchers (Wu and Dunn, 1995; Enarsson, 1998; Carter and Rogers, 2008; Wittneben *et al.*, 2009). The complexity is inherited in the multiple ways in which supply chain processes and logistics affect society and the environment. There are several dilemmas involved in the choice of fuel, the routing of vehicles, the sourcing of material and components, how production is set up, the negotiation of environmental contracts (Murphy and Herberling, 1994) etc. In many ways these contribute to greater or lesser degrees of economic, environmental and social sustainability. Tradeoffs between environmental effects and delivery times (Holweg and Miemczyk, 2002) as well as service levels (Yang *et al.*, 2005) are other challenging examples worth mentioning. Furthermore, several difficulties contribute to this complexity in how to measure and assess the effects caused by different processes and activities within supply chains. McIntyre *et al.* (1998a) highlight the difficulty of measuring logistics environmental performance. While Life Cycle Assessments (LCA) provide valid information about environmental effects for assorted products, they are limited to contemporary flows of goods and demarcated to certain areas (Vieira and Horvath, 2008; Matthewa *et al.*, 2008; Suh al., 2004). Consequently, there are several issues which need to be addressed which cannot be covered easily by LCAs such as the secondary effects of material flows (Johnson and Ferreira, 2001; Wee *et al.*, 2005), the structural setup of logistics activities, the behavioural changes the use of e-commerce contribute to and how all this in turn affects the environment. Jonsson and Johansson (2006) examine the dilemma between social and environmental sustainability where improvements in accessibility and infrastructure may increase mobility, the use of resources, and as a result lead to the deterioration of environmental sustainability. Consequently, a great challenge for supply chain management research and practice is the development of new perspectives, models and tools which can help individuals, companies and supply chains to deal with the increased complexity sustainable development brings. The reductionist paradigm inherent in most logistics research (Nilsson, 2006) must be challenged, and novel approaches which do not try to eliminate but instead comprehend the complexity are needed.

P2: For the integration of sustainable development into supply chain management to become reality, holistic models and perspectives in which comprehension, not elimination or reduction, of the emergent complexity needs to be explored, developed and used.

Operationalisation

The operationalisation of sustainable development in supply chains is another challenge which emerged from our systematic synthesis of the relevant literature. In the literature two main factors are identified which contribute to the challenge of making sustainable development operationally feasible in supply chains; interpretation and inertia. Based on the complex nature of sustainable development the interpretation of what it means in different parts of an organisation or supply chain is difficult to comprehend. While everyone can agree on the Bruntland definition (World Commission on Environment and Development, 1987) it is far more challenging to translate the economic, social and environmental dimensions into relevant and prioritised activities for every process and/or individual in a supply chain. As a

consequence of the difficulties in interpretation, environmental issues are generally neglected or unrecognised in the design (Murphy and Richard, 2003), legislation (Livingstone and Sparks, 1994), or policies (Murphy *et al.*, 1995) of logistics systems. This difficulty of interpretation might be one reason to explain the perceived lack of priority for sustainability issues at the senior level in companies, and the reluctance to turn intent into action (Preuss, 2009; Lyons, 2004; Himanen *et al.*, 2004). Inertia, being the second factor which limits the operationalisation of sustainable development in supply chains, is highlighted several times in literature. A fear of change connected to difficulties of interpretation, the complexity involved, and the underlying business logic with its clear focus on financial aspects, all contribute to the inertia in reaching sustainable supply chains (Welford *et al.*, 2003; Jacobs and Greaves, 2003; Kennedy *et al.*, 2005; Keating *et al.*, 2008). Carter and Rogers (2008), as well as Defee *et al.* (2009), put forward inertia as a main obstacle for organisations in adopting environmentally friendly initiatives.

> P3: In order to transform sustainability ideas and theories into action, i.e. be operationalised, the difficulties of interpreting the concept of sustainable development and the inertia of change inherit in the majority of supply chains must be made priority issues for decision- and policy makers.

Mindset and cultural changes

Change of mindset and culture on international, national and organisational levels are other challenges for environmentally sustainable logistics. For example, Wittneben et al (2009) address the increasing reliance on motorised road transport in developing countries as an international challenge while Srivastava and Srivastava (2006), as well as Badami (2005), identify the lack of environmentally sensitively behaviour in India as a national challenge.

On an organisational level several authors also address the need for a change for mindset in order for any major steps towards sustainable supply chains to be made. The lack of engagement by top management in environmentally related issues (Preuss, 2009; Lyons, 2004; Himanen *et al.*, 2004) is one part of this but the challenge goes even further than that. Even if decisions are taken these must be turned into action by the great mass of people working in organisations. Hence, the values and mindsets of co-workers must also be addressed . Huesemann and Huesemann (2008, p.817) state that *"without a significant change in society's values, the current direction of progress in science and technology will only implement the existing values of growth, exploitation, and inequality, thereby accelerating our approach to collapse."* One assumption forming the mindset of supply chain management is the collaboration for the good of all parties in the chain. This assumption provides a rather "romantic" view of supply chains and is vastly apparent in articles of type one while less emphasised in articles of type two. Instead, in articles of type two, a harsher picture of the activities and collaboration in supply chains is put forward, e.g. power distributions, transaction of cost, etc. An example seen in the supply chains of fresh fruit, e.g. grapes, in which producers (found in less developed countries) are forced to pay for audits performed to be accredited and do not get paid until consumers have bought their products in Europe (Vermeulen and Seuring, 2009). Furthermore, the producers also carry all the risk in the supply chain as damaged goods and lost goods will not be paid for by other members downstream in the supply chain (Ras and Vermeulen, 2009).

Consequently, there is a great challenge in incorporating sustainability and environmental management principles into the daily decision-making process and the processes carried out

in supply chains. For this to happen, the mindset of supply chain managers and logisticians needs to be changed and assumptions taken for granted have to be continually reassessed, both by top management and by the co-workers performing the actual work. As a result, the fourth proposition reads:

> P4: For sustainable development to be a natural part of future supply chains the mindset of people within organisations, supply chains and nations needs to be critical, creative and incorporative of sustainability perspectives and assumptions.

Uncertainties

A collection of articles pinpoints uncertainty as a barrier to developing environmentally sustainable activities. Murphy *et al.* (1995) consider 'uncertainty as to the degree and nature of government regulations' as an obstacle to establishing environmental policies. Rodenburg *et al.* (2002) develop policy scenarios for achieving sustainable transport in Europe highlight substantial uncertainty in long-term development. The challenge of uncertainty can also be found in a number of articles, especially those related to reverse logistics. For instance, Hanafi *et al.* (2008) refer to quality and timing uncertainty of returned products. Inderfurth (2005) discusses about uncertainty in returns and demands as a considerable obstacle to following environmentally benign recovery strategy within a reverse logistics system. Uncertainty in different types of environmental effects of logistics is also a challenge raised by Gilmour *et al.* (1995).

The literature reviewed raises a number of uncertainties related to government actions and decisions, consumer behaviour and demands, and competitive advantages and strategies formulated by organisations. The impression from a number of articles is that this great uncertainty is a barrier to change as it is not clear which part of society will take the first real moves. Hence, in a Kuhnian sense (Kuhn, 1962) the uncertainty experienced with sustainable development might call for a paradigm shift. Similar to the challenge of complexity (definitively a correlated factor to uncertainty), uncertainty is a matter of fact in sustainable development as it is novel to mankind and challenges some of our basic assumptions. Consequently, for research and practice a fifth proposition is made:

> P5: In making supply chains sustainable, organisations must take advantage of uncertainty by exploring, developing and communicating different business logics, and from these, establish new ethical, environmental and social programmes and policy measures.

Concluding discussion

This paper set out to explore themes and challenges in making supply chains sustainable. Based on a systematic review and content analysis of 190 articles from 18 journals we are able to report on what the themes related to sustainable supply chains, logistics and transport have been and currently are in the literature we reviewed. From this analysis, missing themes, as well as the identification of five main challenges for the field of supply chain management, have been provided together with suggested research propositions which provide guidance for further research and practice.

Development of supply chains in a sustainable and environmentally friendly way is complex. The diversity and the nature of identified themes and challenges is evidence of this claim.

Both environment and supply chains consist of gigantic subsystems as well as massive processes and resources which make management of their development fairly complex. The difficulties in demarcation of supply chains and natural environment, as well as the existence of paradoxes (Enarsson 1998; Murphy and Herberling 1994) reveal complex attributes, too. Challenges of changing cultures and mindsets, difficulty in control and management of uncertainties and tradeoffs are other examples of the complexity of this area. The complexity of problems and challenges makes agreements about the priorities for action and policy initiatives very difficult (Brown, 2005). In conclusion, there is a great need for models and frameworks which consider the complexity involved, take holistic perspectives, and challenge the basic assumptions underlying most of the research published (i.e. reductionism, positivism and economic growth). Furthermore, based on the propositions put forward in this paper both managers and policy makers can be guided as to the extent and areas that changes need to be addressed. For policy makers there is a need to deal with uncertainties as many companies are still at the stage of compiling laws and regulations. In setting policies which can guide and mitigate uncertainty, companies can adapt to the policies and be willing to invest more in order to gain a competitive advantage. However, these policies need holistic thinking and research models which can deal with the complexity related to sustainable development. Otherwise, the risk is that suboptimal policies might be manifested which undermine the purpose of sustainable development. For managers, operationalisation is mandatory since the policies set must be transformed into purposeful actions by every actor and participant in the supply chain. In this operationalisation, the issues of social and environmental sustainability must be prioritised as highly as financial issues are today.

One limitation of this study is, of course, the number of journals included. Choosing six of the highest ranked and most-cited journals from each of the three types was to balance rigour and feasibility, i.e. more journals might have increased the number of articles which would theoretically have been good, but practically, would exceed the amount we would be able to review and analyse in a reasonable time period. A sample of fewer journals might, on the other hand, mean that we would miss some important aspects. Consequently, we encourage further research to review a much broader sample of journals but over a limited period of time.

As a final comment, we argue that sustainability should be integrated into supply chain management and not be treated as a concept or theory of its own (like sustainable supply chain management, environmental logistics management). This separation, of as literature today manifests, identifies sustainability as a factor of its own; an add-on to SCM. Instead, environmental and social issues should be treated in SCM in the same way as revenues and costs are today. Otherwise, sustainability will only be an add-on which will be given lower priority in research, boardrooms and management teams.

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Paper II

"Themes and challenges in making freight transport sustainable"

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THEMES AND CHALLENGES IN MAKING FREIGHT TRANSPORT SUSTAINABLE

A logistics service providers' perspective

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ABSTRACT

The purpose of this article is to explore themes and challenges in making freight transport sustainable out of a logistics service providers' perspective.
The approach is explorative and the main method for data collection is interviews. The study has a cross sectional design which takes advantage of nine semi-structured interviews from selected logistics service providers operating in the Scandinavian countries.
Our findings illustrate the major themes of sustainable freight transport, by analyses of current as well as future activities, in perspective of nine interviewed logistics service providers. In addition, the patterns of current and probable emerging challenges for developing sustainable freight transport were discovered. It is concluded that there is great need for a holistic perspective where logistics service providers and product owners together analyse and design future freight transport set-ups. The analysis of complex interactions among LSPs and other actors of supply chains provide several opportunities for future research.
The results offered in this paper provide a systematic structure for classifying issues related to sustainable freight transport; something which will be beneficial for managers and policy-makers when they approach sustainable supply chain management challenges. Syntheses and discovery of themes and challenges of making freight transport sustainable are critical for a sustainable society. This paper combines the results from interviews with a thorough review of related articles and homepages. The study ends with research propositions contributing to the further advancement of supply chain sustainability and management.

Keywords: logistics, freight transport, logistics service provider (LSP), third party logistics, sustainability, environment

1. INTRODUCTION

The role of transport in the global societies of today is mandatory but not without negative effects. On the positive side, transport generates accessibility and mobility, which is essential in today's dynamic social life. Without transport, humans/passengers turn to static creatures and products/freight turn to stationary raw materials. Furthermore, transport leads to social as well as economic development. Due to transport, infrastructures are constructed; jobs are created; and new vehicles are generated. Moreover, growth in transport is an inseparable part of growth in economy. Transport is one of the enablers of world trade, globalization, and industrialization. According to European Union (2011), the transport industry directly employs around 10 million people and accounts for about 5% of GDP in the EU.

While being economically and socially feasible, transport and environment have several negative impacts on each other. Natural disasters (like flood, earthquake, volcanic eruption, and tornado); rust, corrosion, sudden temperature changes, shock, and stress are just some negative effects of environment on transport to mention. On the other hand, transport activities have different negative impacts on the environment. Conservation of resources (energy, materials, etc.), pollution, emissions, noise, congestion, and waste disposal are some exemplary negative impacts (World Business Council for Sustainable Development, 2004).
Transport activities are some of the main sources of emissions of greenhouse gases (GHG), mostly CO_2. According to IPCC (2007), in 2004, transport sector produced 6.3Gt CO_2 emissions and was responsible for 23% of world energy-related GHG emissions with about three quarters coming from road vehicles. Over the past decade, transport's GHG emissions have increased at a faster rate than any other energy using sector (IPCC, 2007) and is still representing the fastest-growing in the future (Brown, 2005). Transport activities are expected to grow robustly over the next decades. As a result of this growth, in a business as usual scenario, an annually increase of world transport energy use by 2% as well as 80% higher total transport energy use and carbon emissions in 2030 than 2004 levels is predicted (IPCC, 2007). Freight transport has been growing even more rapidly than passenger transport and is expected to continue to do so in the future. In EU, for example, the demand for freight transport is expected to grow on average by 2.7% per year. Globally, freight transport is expected to grow from approximately 15 trillion ton-kilometres in 2000 to around 45 trillion ton-kilometres in 2050 (World Business Council for Sustainable Development, 2004).

Sustainable development of transport calls for developing activities which lead to highest economic and social gains while diminishing the negative environmental losses. However, sustainable development of transport activities in the long term is complex and tied with tremendous challenges, dilemmas, difficulties, and barriers. Governance (McCauley, 2008); migration and internal mobility, aging, urbanization, and globalization are some challenges towards social and economic developments (European Union, 2011). Challenges towards environmentally sustainability may relate to increasing cost, complexity, operationalization, mindset and cultural changes, and uncertainty (Abbasi and Nilsson, 2011) as well as increasing scarcity of fossil fuels and global warming (European Union, 2011).

The purpose of this article is to explore themes and challenges in making freight transport sustainable out of a Logistics Service Providers' (LSPs) perspective. Freight transport services offered by Logistics Service Providers (LSPs) are the main focus of this study. The main reasons to focus on freight instead of passenger transport are higher complexity as well as less research on sustainability promotion and polices (Wigan and Southworth, 2004;

Himanen et al., 2004; Lieb and Lieb, 2010). The main reason for such perspective is increasingly outsourcing of logistical services to LSPs (Wolf and Seuring, 2010).

In the next section, a brief frame of reference is provided to review some previous research on connection of logistics and freight transport to sustainable development as well Logistics Service Providers (LSPs). From this follows the method. The research is mainly based on semi-structured interviews from selected logistics service providers operating in the Scandinavian countries. Emergent themes of sustainable freight transport are thereafter presented, followed by challenges identified from which further discussion are drawn. The paper then ends with concluding remarks and opportunities for future research.

2. SUSTAINABLE DEVELOPMENT AND FREIGHT TRANSPROT

Although there is not a universal definition of concept of sustainable development (Björklund, 2005; Pihl, 1997; Pezzy, 1992), the most popular and widely accepted is that of Brundtland report "*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (World Commission on Environment and Development, 1987, p.8). According to Björklund (2005), the origin of concept of 'sustainable development' dates back to 1970s, when it appeared among professionals in environment and development circles. However, it became widely spread and well-adopted when the United Nations at the Earth Summit in Rio in 1992 quoted Brundtland report's definition of sustainable development (Anderson et al., 2005).
Following the United Nations 2005 World Summit, sustainable development encompasses the interdependent and mutually reinforcing pillars of economic development (Profit), social development (People) and environmental protection (Planet). The three 'P's of sustainability are sometimes called the 'three bottom lines (TBL or 3BL)'. The three bottom lines have begun to appear in the literature of business disciplines, such as management and operations, while adapted by companies (Carter and Rogers, 2008). Jeffers (2010) uses 'corporate sustainability' as a similar concept to the three bottom lines and conceptualizes it *"as a dynamic process with the stated aim of allowing business entities to realize economic objectives that potentially can improve the quality of life for its stakeholders, while simultaneously protecting and enhancing the earth's life support systems".*

Literature of logistics and supply chain discipline also show an increasing appearance of sustainable development where all its three pillars (Carter and Rogers, 2008) or just some pillars such as corporate social responsibility (Keating *et al.*, 2008; Dyllick and Hockerts, 2002); environmental logistics (Wu and Dunn, 1995); Green logistics (McKinnon et al., 2010; Abukhader and Jönson, 2004; Aronsson and Huge Brodin, 2006) have been presented. However, literature on environmental/green- logistics and supply chains are more dominant than wider sustainable- logistics and supply chains. In addition, phrases such as environmentally- sustainable / friendly / sound / preferable / responsible, eco, and green are found to be widely used synonymously (Abbasi and Nilsson, 2011; Björklund 2005).

Sustainability and freight transport, in more specific than logistics and supply chain, have been discussed in literatures in several ways. Some literatures have modified definitions and aspects of sustainable development in context of transport (Black, 1996; Richardson, 2005). The others have used similar or reflected upon specific concepts such as sustainable mobility (Gudmundsson, 1996; Banister et al. 2000; World Business Council for Sustainable Development, 2004), environmental sustainability (McKinnon et al., 2010), transport and climate change (Chapman, 2007), energy efficiency and emissions (McKinnon, 1993), etc.

Based on principles of division of labor and knowledge, companies are increasingly outsourcing their logistical services to LSPs/3PLs. According to Stefansson (2006), *"the degree of outsourcing varies and the outsourced activities differ greatly in complexity"*. Some examples of activities mentioned in literatures are: transportation, storage, and warehousing (Wolf and Seuring, 2010), packaging, freight forwarding, and inventory management (Liu et al., 2006), cross-docking at terminals or consolidation services at distribution centers (Sternberg, 2008), managerial activities related to flows of goods and production (Fabbe-Costes et al. 2009), and value-added activities such as merge-in-transit setups (Stefansson, 2006).

Although outsourcing activities and role of LSPs in creation of trust and value in supply chain is becoming increasingly important, researched-based studies are evidence that very little attention has been given to sustainability goals and aspects (Lieb and Lieb, 2010; Wolf and Seuring, 2010). According to Wolf and Seuring (2010), transport activities of LSPs are the single largest source of environmental hazards and CO_2 emissions in logistics industry.

3. METHODOLOGY

Researching sustainable development in the context of supply chain management and logistics is not easy due to the many aspects and trade-offs that need consideration. This is also the case in practice. Cruz et al. (2006, p.872) state that sustainable development is *"perhaps one of the most complex and important demands that has occupied managers' reflection"* and Hall and Vredenburg (2003) report that managers have great difficulties in dealing with sustainable development. Consequently, in researching themes and challenges confronted by logistics service providers (LSPs) in making goods flow sustainable, an explorative and mainly qualitative method was found most appropriate. Inspired by grounded theory (Glasser and Strauss, 1967; Charmaz, 2006) and the way the methodology been used in logistics research (Nilsson, 2006; Flint and Golicic, 2009), the research was designed as a combination of interviews, secondary data from homepages and reports, and literature studies. The interviews have been the main source of data.

3.1 Interview study

The interview study was designed based on the seven stages of a qualitative interview investigation suggested by Kvale and Brinkman (2009), namely: thematizing, designing, interviewing, transcribing, analyzing, verifying, and reporting. Furthermore, in line with the case study procedure suggested by Yin (2003), three documents were created in the design of the interview study; an interview study protocol, an interview study database, and an interview study report, in order to secure high quality research. The interview study protocol has had two major purposes; 1) to document all relevant information in making the process of the interview study as effective and efficient as possible (overall purpose of the study, names, addresses, maps, interview questions etc.), 2) as a log-book where impressions and experiences from each interview and company visit were documented. The interview study database had the purpose of collecting the bulk of material that we investigated. In this database the raw data (company reports, homepage documentation, sound files, transcriptions, presentations, photos etc.) that were used are collected during the research process. With the data and information enwrapped but not interpreted it is beneficial in order to go back to the source when doing the analysis. The final document used in the research is the interview study report. This became in the end an approximately 200 pages report encompassing all the material in an interpreted and analyzed form. Here the results from the coding processes as well as the connections found to previous research are reported.

3.1.1 Thematizing and designing

Based on our earlier research and experience of sustainable development in the context of logistics together with a number of discussions and seminars with logistics managers it was found that there are several challenges in making freight transport sustainable. Looking at supply chains, the main actor in freight transport is the logistics service providers (LSP). Hence, in an explorative manner it became natural to get a LSP perspective on the challenges of sustainable freight transport. In order to get a comprehensive and doable sample the research has been focused on LSPs active in Scandinavia. We set out with a list of 30 LSP companies. The list included both small and large LSPs. Then, as a combination of snow ball sampling and earlier contacts at the LSP, we ended up with a list of interviewees. Each potential interviewee was first contacted by an e-mail, in which the purpose of the study, a description of the research area (sustainable freight transport) and an invite to an interview was included. This was then followed up by telephone call in which any extra information was given and dates set for the interview was made. In total we have interviewed twelve logistics and/or sustainability managers from nine LSP companies (DHL, Maersk, Schenker, Green Cargo, Bring, DSV, Transport ledet, SAS Cargo, and Lastbil centralen). The majority of the interviewees had long experience (20 years or more) of sustainability as well as transport and logistics operations. Most of them had a top management position for the regional LSP offices for the Scandinavian market (if the LSP was part of an international organization) or in the management team (for those operating in one nation).

The data collection process ended when saturation was reached. After interview seven, we evaluated the process and got a first feeling that no more significant or new information was really gained for the purpose of our study. To secure the research quality, two more were conducted, from which we then concluded that data saturation was reached. The sample size for this type of research is according to McCracken et al. (1990) eight for homogeneous samples and Carter and Jennings (2002) suggest 12-20 for heterogeneous samples. In this case the companies and interviewees operate in the same geographical regions, working on similar issues. Hence, compared to more global studies or studies in different industries the sample might be regarded as homogeneous.

3.1.2 Interviewing

The interviews were semi-structured, including both open ended questions and a questionnaire at the end. The interviews lasted for about 90 minutes. An interview guideline was created for the open-ended questions divided into three major areas, namely: the current activities for sustainable development, the future activities and trends for sustainable development (till 2050), and the challenges of sustainable development. The discussions focused on these areas for LSPs specifically and for freight transport in general. Prior to each interview an in-depth study of each LSPs home page was made and information about the company in general as well as information about sustainability related activities, statements, reports, etc. were compiled. All relevant information was documented in the interview study database so it could be accessible in alter phases of the analysis.

3.1.3 Transcribing

Every interview was taped and there after transcribed. If there were any possible misinterpretations or question marks found during the transcriptions, follow up contact was made with the interviewee. Interviewees were asked to read the transcribed text and send the reviewed transcription to the authors. Each sound file as well as transcription was then placed in the interview study database.

3.1.4 Analyzing

The principle of grounded theory is that sampling, and data collection and analysis are interrelated and carried out simultaneously (Glasser, 2002; Corbin and Struss, 1990), which has been the case in this research as well. The analysis of the interviews was conducted during the whole process and included the use of secondary material such as reports, homepages, and documentation. The analysis was inspired by principles of discourse analysis suggested by Winther and Phillips (2000). The initial analysis followed the three areas for the interview i.e. the current- and future activities towards sustainable development, and the challenges confronted. This involved a coding process (an open coding) where different themes in each category emerged as well as for the challenges. A second step of the coding, focused coding (Charmaz, 2006) resulted in the major themes being reported in this paper.

3.1.5 Verifying

The results of the analyses of interviews were discussed several times between authors. With help of secondary sources, syntheses of analyzed interviews were conducted. After verification of results by authors, the interviewees were asked to verify their quality; i.e. trustworthiness and authenticity. The verified results were then used as input text for this article.

3.1.6 Reporting

In line with Kvale and Brinkmann's (2009, pp. 272-277) guidelines for structuring an ethical interview report, this article and its structure are embodiment of the task. The results of the analyses are reported from logistics discipline and Meta levels (Nilsson, 2005, pp. 176). The report of this interview study is mainly used for our own research purposes. However, the final report is sent to all the interviewees and used for scientific communication with other researchers.

3.2 Research quality

Two criteria for evaluating quality of our qualitative research are adapted; namely authenticity and trustworthiness (Bryman and Bell, 2007). To increase authenticity of our interview study, different measures were considered. In thematizing and designing phase, comprehensive literature review as well as further discussion with researchers were conducted to be sure that the perspective should be on LSPs and right amount of the right ones should be interviewed. For the interviewing phase, right interviewees were contacted whom interview introduction and guideline were sent in advance. Both the interviewers and interviewees did their best to communicate enthusiastically and use their best conversation and language skills. To increase trustworthiness in interviewing phase, homepage, relevant reports, and documents of each LSP were read in advance. This could decrease the bios from interview protocol as well as mismatch of understanding among interviewers and interviewees. In transcription step, the sound files were reliably saved in the study databases. In other steps of interview, the interviewees were contacted to verify the transcribed texts as well as the synthesized version of the study. For sake of research ethics, the interviews transcriptions are kept confidential.

4. ANALYSIS

After as well as in parallel with data collection, data analysis was run in order to find answers for research questions. The analysis after focused coding can be divided into three sections: current- and future activities as well as challenges in making freight transport sustainable.

4.1 Current activities in making freight transport sustainable

Most of the interviewees have recognized triple bottom lines in the Brundtland Commission's definition of sustainable development. However, ecological/environmental aspects as well as long-term economic sustainability were more explicitly mentioned in interviews than social aspects. This is in accordance with Carter and Roger s' (2008) and Seuring and Müller s' (2008) findings. Although all LSPs have plans and objectives for sustainable development, just a few of them have entered such objectives to their mission or vision statements. In addition, just one LSP has designed its business model based on principles of sustainable development especially when it comes to green and environmentally friendly offers.
The analysis of current activities results in eight categories (summarized in table 1). Three of these have been most emphasized by most of the interviewees (primary activities) while the other five have been less emphasized (secondary activities). In this article, just the primary activities are elaborated in details. However, very short exemplary explanations of secondary activities are presented inside parentheses in table 1.

Table 1 – Current activities in making freight transport sustainable from LSPs' perspective

Primary activities	Secondary activities
Resources efficiency, effectiveness, and utilization	Taking initiatives *(UN Global Compact, UN Development Program (UNDP), Logistics Emergency Teams (LET))*
Environmentally/sustainability cautious behavior	Compliance with legislations and standards *(ISO 14001, EMAS certification, Sulfur emission- and Ballast water legislations by IMO)*
Measurement and assessment	Efficient utilization of transport infrastructure *(Single sky, Coordinated air traffic control)*
	Well-connected information and goods flows *(By implementing 'Intelligent Transport'- or 'Track and Trace' systems)*
	Vertical and horizontal collaboration *(Collaboration and Lobby work with other LSPs , authorities, and stakeholders)*

Resources efficiency, effectiveness, and utilization

These are the efforts which aim to increase efficiency, effectiveness, as well as utilization of logistical (including transport) resources. Effectiveness means doing the right things while efficiency is defined as doing things right (Nilsson, 2005). The resources considered by interviewees are just the physical ones (Magnusson, 2008) which can be movable or static.

A) Efficient- and effective- movable resources

From LSPs point of view, resources' effectiveness – which means using the right resources – as well as their efficiency – which means using the resources right – can contribute to sustainable freight transport. The most common activities to increase effectiveness and efficiency of freight transport resources are as follow:

- Right mode of transport (intermodality): These are related to efforts which aim to find the right combination of available modes which may fulfill the transport demand with the right cost at the right time with lowest negative environmental effects. All LSPs take advantage of several modes of transport in their operations and aim to continuously improve efficiency of each mode.
- Using environmentally friendly vehicles like Electrical trains and EU 5.0 trucks with the lowest energy/fuel consumptions.

B) Efficient static resources

Several LSPs have started to be energy- and eco-efficient by acting more responsible with/in their static resources like terminals, hubs, distribution centers, warehouses, offices, etc. Some exemplary parameters are reducing electricity consumption by using low energy lamps, decreasing waste of energy by using light and temperature sensors, recycling as well as reducing consumption of paper and plastic. One of the interviewees adds: *"It is also very important to visualize energy- and eco-efficiency and letting all personnel to access it. This can make the staffs more responsible with consumption of resources".*

C) Higher resource utilization

To increase the utilization of movable and static resources is another effort of LSPs towards sustainable freight transport. Higher resource utilization may increase load factor, fill-rate, efficiency, as well as economic benefits (in line with findings from McKinnon et al., 2010). On the other hand, it may decrease fuel/energy consumption and GHGs emissions per ton -, volume -, or TEU (Twenty foot Equivalent Unit) - km. According to one of the LSPs with core competence in sea transport, *"the fill-rate is a very important factor of making the consumption per transported unit lower but also to improve the income. In order to increase the fill-rate, we do triangulation and try to decrease imbalances in goods flows. However, we can still increase the fill-rate inside each unit load, like container, if we collaborate directly with our customers while they fill the unit loads/ containers".*

Environmentally/sustainability cautious behavior

LSPs have started programs which aim to make the behavior of stakeholders more environmentally/sustainable cautious. Some examples are:

- Educating all personnel about ethical and environmental operations; like 'GoGreen' and 'GoTeach' programs started by DHL.
- Training all fleet personnel for 'eco-driving' in road and rail transport, 'eco-sailing' in sea transport, and 'green- take off and approach' in air transport.
- Responsible sourcing/ procurement in order to scan all suppliers to assure that they fulfill social and environmental (corporate social responsibility) requirements. One of the interviews elaborates further by mentioning: *"What we do is that we make risk assessment on each supplier and if we find that there is a risk connected to that supplier, we work further with the supplier until we have either decided that there is not any risk or irresponsible behavior".*

Measurement and assessment

Measurement and assessment are inseparable activities of LSPs towards sustainable development. As one of the interviewees mentions: *"We have developed an internal standard as well as scorecards regarding how to collect and measure different kinds of parameters connected to sustainability".* Some LSPs have taken advantage of independently verifying authorities for execution of such activities. One of the interviewees emphasizes: *"we would like that all measures and figures be checked by independent parts. For example, we have made sure that our, [as start] CO_2 emissions, figures are independently verified by Lloyds-registered quality assurance […] we are also asking our clients to ask for similar independently-verification for our competitors' figures… so, the figures are really accurate and possible to use in real benchmarking … because we believe that we have figures that you can trust and can be used for your procurement process and that will also drive performance. So, that's one of our ideas on how to bring the whole industry towards more sustainable shipping".*

All LSPs collaborate actively with other stakeholders to increase validity and reliability of their emissions calculations. Four out of nine interviewed LSPs offer online platform for calculation of GHG emissions from transport operations.

Furthermore, eight out of nine interviewees publish annual sustainability reports which are openly available for customers/clients and other stakeholders.

4.2. Future activities in making freight transport sustainable

All the interviewees agreed upon tremendous difficulty and uncertainty in design of future sustainability-related activities and strategies for freight transport in a long-term perspective like 40 years from now (till 2050). However, they took a shorter perspective (till 2020) to elaborate on future activities and strategies.
The analysis of future activities results in seven categories (summarized in table 2). Three of these have been most emphasized by most of the interviewees (primary activities) while the other four have been less emphasized (secondary activities). In this article, just the primary activities are elaborated in details. However, very short exemplary explanations of secondary activities are presented inside parentheses in table 2. Worth mentioning that all LSPs are going to continue their current activities in making freight transport sustainable mentioned in section 4.1.

Table 2 – Future activities in making freight transport sustainable from LSPs' perspective

Primary activities	Secondary activities
Innovation and research	Technological development *(Development or adaptation of 'Transport Management System's (TMS), 'Intelligent Transport Systems' (ITS),'Enterprise resource Planning' (ERP)*
Energy/fuel efficiency	Design for sustainability *(Better design of supply chain statics like number and arrangement of terminals, hubs, distribution centers, etc.)*
Increasing awareness	Adaptation to future policies and corporate governance *(Collaboration with authorities and policy makers regarding coming policies and directives)*
	Taking supply/ value chain view *(Collaboration with products' producers/manufacturers and consumers as well as passenger carriers)*

Innovation and research

Innovation is going to be on the agenda for sustainable development all the time. LSPs are going to be always open to innovative solutions, strategies, out of the box ideas, and business models which may develop sustainability of their businesses in both short- and long-terms.
In addition, they are going to invest heavily in research and collaboration with researchers and advisory councils. Research may smooth the path towards innovation. As an example, one of the LSPs with core competency in sea transport elaborates on role of innovation and research on energy consumption of vessels by stating: *"long-term investments in research, technical developments, and innovation are behind our strategies towards reduction of [total] energy consumption […] we would like to be pioneer, prime mover, in reduction of emissions".*

Energy efficiency

Energy will be an inseparable part of transport. Based on principles of *peak oil (*Chapman, 2007); oil production will begin to fall during the coming years. With regard to this, finding proper replacement of energy produced from renewable sources as well as taking plans for higher energy efficiency in transport sector is a must. LSPs show the path to this trend by reflecting upon one or some of the following issues:

- To energize and utilize resources like vehicles and facilities which are fed by non-fossil/renewable while economic fuels.
- Collaboration with vehicle manufacturers - Volvo and Scania were oftentimes mentioned - in order to design more environmentally friendly trucks, trains, vessels, and aircrafts which, for example, are lighter and more aerodynamic, have more efficient engines, emit zero GHG emissions.
- To move towards zero emission from energy production and consumption. In this regard, LSPs are going to collaborate with base industries, like energy producers, to find alternative fuels which are produced without using raw material from food sources or endangering forests or the biodiversity. As one of the interviewees signifies: *"It is very important that renewable energies be globally and ethically produced in way which does not increase GHG emissions.* One of the LSPs with core competency in sea transport adds: *"we do not believe in substitution of fossil fuel to bio-fuel on a short term basis because we believe that, in the short perspective, it is impossible to change/ switch such a huge amount of energy that is used in shipping […]but we would like to be prepared in the future; we would like to be sure that when we switch or start switching, we have fuel that is sustainable […] so, it is not that we discover after a year or two that we killed the possibility for people of this part of the World, to have food or we have cut down rainforest, or whatever things that can happen. […] To find fossil-free fuel which can be produced in enough quantity without other external negative effects is very tricky… So, I don't believe that we can switch on short-term base but on the long-term base. So, we are preparing and trying to find"*.
- To benchmark energy efficiency with other businesses as well as investment on innovation, research, and technical development for less and higher energy consumption and efficiency, respectively were also lifted by several interviewees.

Increasing awareness

Awareness makes the path towards adaptation of new solutions and policies as well as change of behavior smooth. LSPs are going to work with other stockholders in organizational, national, and international levels to increase awareness of new generations about dimensions and importance of sustainable freight transport/logistics. According to one of the interviewees, *"In general, we have been much more aware of sustainable development after Al Gore and IPCC Nobel peace prize in 2007. In fact a new world has been opened. I think that future generations will be still more aware when it comes to energy resources, climate change, environment, ethical trade, and so on."*

Lifting awareness of suppliers and customers (Shippers and receivers/ Consignors and consignees) as well as carriers, forwarders, and logistics service intermediaries were elaborated by LSPs several times during the interviews. They also emphasized the significance of change of customers' behavior and outlook when it comes to purchasing sustainable freight transport services. At the moment, cost and time are much more preferred than environmentally friendliness.

4.3 Challenges in making freight transport sustainable

The third part of our interviews focused on the challenges the LSP's perceived in making their operations more sustainable. The following five categories emerged from the analysis:

Business complexity

Finding cooperative ways to develop sustainable solutions is recognized as a major challenge due to the fragmented nature of logistics industry. While all LSPs offer freight transport services by all modes of transport, they typically contract with several logistics service intermediaries (LSIs) (Stefansson, 2006), forwarders and carriers to fulfill their services.

Consequently, management of all LSIs, forwarders, and carriers are challenging, especially when it comes to all pillars of sustainable development. For example, some of the global LSPs complain that it is difficult to follow that all carriers use environmentally friendly trucks like Euro 5.0 class or measure their sustainability performance. Another challenge is that competence of different modes is distributed, something that both have positive and negative effects. For example, one of the LSPs with core competency in rail transport complains that several technical problems by electrical or hybrid trucks have influenced whole of their business brand. Finally, as all interviewees put forward, the sustainability interest of the customers is essential in order to develop and deliver more sustainable solutions. All LSPs put forward that the customers had rather low interest in prioritizing more sustainable transport solutions. Furthermore, the competences related to transport effects on the environment or socially of their customers were also found very fragmented. One interviewee stated that *"Sometimes they have their own environmental departments or groups in their companies, but we have found that they do not speak to each other internally about the importance of environmentally friendly transport."*

Time and cost

"The challenges are mostly about time and price!"(Interviewee number 4). Some LSPs emphasize that today, customers' behavior are in opposite of environmentally cautiousness. Customers usually look at transport as a non-value added activity where it must be fulfilled with the lowest time and price. As a consequence, fill-rates and resource utilization of LSPs are sacrificed. In addition it usually leads to higher emissions and negative environmental impacts. As one of the interviewees claims: *"In conclusion, it is very difficult to balance the cost, time, environmentally friendliness, and at the same time competition with other LSPs."* Consequently, there is great challenge in finding ways to overcome the economically driven solutions. As explained by one interviewee *"...it is not the environmental friendly solutions that should be costly. The non-environmentally solutions should be more costly"* However, as another explained *"we have an eco-friendly solution* […] *which is actually cheaper but then we need more time to plan the transport. But it is not many companies using* [the eco-friendly solution] *even if it is cheaper; Because of time limits"*. Hence, the market needs of timely deliveries are also a challenge to consider.

Managerial complexity

Developing sustainable freight transport services is tied with several managerial challenges. One dimension is difficulties in measurement and assessment. For example, different LSPs use different standards, methods, and platforms for measuring GHG emissions or for assessing environmental impacts of freight transport operations. One of the interviewees from air sector states: *"Together with IATA and Star Alliance, we work with issues like global Emissions Trading Scheme (ETS)… This is an absolute challenge to reach the goals and I do not know if we can succeed!"* Another dimension is different customers' demand in different markets. Working with different types of industries calls for high flexibility of transport system. For example, in some occasions resources are restricted by volume (cubic meter) and in some by weight (ton). Furthermore, change and adaptation take time and in some occasions this is very expensive. All the interviewees highlight the complexity of implementation i.e. it takes long time and is expensive to change the fleet to newer more environmentally ones, adapt to new sustainability legislations, synchronize internal thinking about environment, inform all actors of a global supply chain and sometimes the politicians and decision makers about importance of all aspects of sustainability, get the suppliers to adapt to sustainability criteria, change customers' behavior, etc.

Network imbalance

To balance the goods and resources flows in the network is another identified challenge. Imbalances in goods flows are mostly due to restrictions in the system like delivery at an exact sharp time; daily, and usually diverse, load and unload (pick and delivery) operations; etc. Geographical positions may lead to both imbalances in goods and resources flows. For example, one of the interviewees from rail sector says: *"if you look at long geographical position of Sweden, there are huge amount of goods from Göteborg/Skåne till Stockholm but there are little from Stockholm till Göteborg or from north to south. This can also lead to empty running or imbalance in flows of trucks".* Network imbalances deteriorate fill-rates as well as resources utilization which means higher emissions and negative environmental impacts. The scenario becomes worse when it comes to network imbalances in international markets. Globalization, exports, and fair trade can all lead to imbalances in freight transport network. One of the interviewees from a global LSP company with core competency in sea transport highlights that: *"if you look at global commerce – it is very easy to say that everything should be locally sourced … but you should have in mind that no country has ever got from extreme poverty to developed country without a very heavy commerce with other countries."*

Uncertainties

Uncertainties about future fossil-free fuels and infrastructural changes for production of such fuels, especially in global markets, are very challenging. One of the interviewees states: *"My guess is that finding a fossil-free fuel for the future is not easy […] so, if we can cut the consumption, that is really very good but to take it to the very far end to find fossil-free fuel that be produced in enough quantity without other external negative effects is very tricky*. Other dimensions of uncertainties are related to future changes in transport infrastructure. Taking initiatives like investment in new infrastructures or combination of passenger and goods transport infrastructure, for example transport in city by rail, are tied with tremendous uncertainties. Uncertainty in legislation and regulations is also a challenge emphasized by the interviewees. Without clear and long-term directions from regulators the willingness in the LSP industry to take risks in increasing transports by train, go for bio-fuel alternatives, etc. are low. As explained by one interviewee *"regulators and governments must create concrete strategies and stay with these".*

5. DISCUSSION

In order to tackle the challenges in making freight transport sustainable, there is a great need for holistic models together with long term perspectives in which comprehension, not elimination or reduction, of the emergent complexity that sustainability represents is explored. Without such perspective, the decision- and policy making will be suboptimal. By analogy, LSPs must also take a holistic perspective to whole of the supply chain in order to avoid suboptimal and isolated decisions for sustainable development of freight transport. A future step may be the analysis and design of future freight transport set-ups in collaboration with products' producers/manufacturers, end- tiers consumers, and passenger carriers.
In addition, there are just few LSPs who have taken part in sustainability initiatives. A more proactive approach to such initiatives may lead to bottom-up changes towards sustainability and increase the chance of operationalization of bottom lines of sustainable development.

The identified themes, the current and future activities, also represent the importance of an integrative perspective. It is clear that sustainable freight transport can never emerge by just

one activity or operation. There is great need for developing a packet of solutions with different activities which do not have conflicting goals or effects on each other. The solutions for making freight transport sustainable can be classified in three major areas: Adaptation, Reduction, and Optimization. These three areas may be considered as macro solutions towards sustainable supply chains and be used by decision- and policy makers.

Adaptation: Adaptation refers to those types of solutions which seek opportunities for changing the supply chain actors' behaviours in both short- and long-terms. Taking initiatives, compliance with legislations and standards, sustainability cautious behaviour, collaboration, and innovation can all be classified under solutions towards adaptation.
Reduction: It relates to efforts which aim to reduce consumption of materials and resources of the Earth. The simple equation behind this solution is that by reducing demand, supply will be reduced as well. Less demand means less consumption of natural materials, products, packages, energy, transport, resources, and so and so forth. Less consumption may decrease the amount of green-house-gases (GHG) emissions.
Optimization: An obvious conclusion from the last section is that although consumption of materials and resources of the Earth can be reduced, they can never be completely omitted. To imagine a world without demand for materials, foods, packages, energy, and transport sounds even impossible. Optimization relates to those solutions which aim to find opportunities for optimizing consumption of materials and resources of the Earth. The result will be finally less consumption and green-house-gases (GHG) emissions.

A very dominant pre-assumption in developing sustainable transport is that more environmentally friendly modes should be used. This may be true in the short-term but the standpoint made from our analysis is that it will not solve the problem in the long-term. The transport system must be developed in a resilient way. This means that in case of peak loads for one mode, the other modes must be ready to be replaced. Peaks can happen due to natural disasters, weather conditions, risk and security reasons, terrorist attacks, etc. In addition, optimal competition among transporters, and modes of transport, may decrease the price of transport service for the customers.
Some interviewees raise another dimension which is related to geographical restrictions or distribution of the resources of the world in a way which is impossible to reach by all modes or can be reaching by just one mode. For example, one interviewee states: *"There are not so much rail opportunities in Denmark in compare to Sweden and that is mostly related to how its geography looks like".* Another one with core competency in air transport mentions: "*In north parts of Norway, the only mode of transportation is either by car or the aircraft. So, if we do not fly, then the society there will almost stop".*

6. CONCLUSIONS

In this paper we have explored major themes as well as pattern of current and emerging challenges for developing sustainable freight transport out of a LSPs perspective. A major conclusion drawn from the findings is that sustainability issues out of a LSP perspective have a strong tendency towards economic/profit related issues followed by environmental concerns and thereafter social/people related. It is also a conclusion that the LSPs recognise cost and time to be of major importance to their customers and most of them feel that their efforts in providing more environmental solutions do not pay off since it is not prioritized if it is in conflict with either cost or time. Furthermore, there are a number of uncertainties that restrain LSPs such as uncertainty in technological development, regulations and legislations, and the

movement of their customers. Further research is needed in understanding the interrelationship between LSPs and their customers in the development of sustainable logistics solutions as well as the role and importance governments have in reaching the goals of 90% CO_2 reductions before 2050.

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Paper III

"Themes and challenges in making urban freight distribution sustainable"

Authors: Maisam Abbasi and Mats Johnsson

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THEMES AND CHALLENGES IN MAKING URBAN FREIGHT DISTRIBUTION SUSTAINABLE

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ABSTRACT

Purpose
The purpose of this article is to explore and classify themes and challenges in making urban freight distribution sustainable.

Design/methodology/approach
The study has a cross sectional design which started by a narrative literature review and analysis of a sample of related literature (like peer-reviewed articles and EU (European Union) documents). It ended with complementary discussion and recommendation for tackling the challenges.

Findings
The results of the study illustrate eight and seven emerged categories of themes and challenges, respectively. It is concluded that there is great need for a packet of mixed strategies as well as a more holistic perspective where all actors together analyse and design future set-ups and operation of urban freight distribution. Such a holistic view is essential in order to: understand how different actors of the chain look upon sustainable urban freight distribution, avoid sub-optimal policies/governing rules, and suggest close-to-reality solutions for tackling the challenges.

Research limitations/implications (if applicable)
Freight distribution in urban areas is the main focus of this article. In addition, the study is demarcated to eco/environmental aspect of sustainability although it is impossible to completely exclude its interaction with economic and social aspects.

Practical implications (if applicable)
The results offered in this paper provide a systematic structure for classifying issues related to sustainable urban freight distribution; something which will be beneficial for managers and policy-makers when they approach sustainable supply chain management challenges.

Originality/value
This study provides a synthesized classification of themes and challenges which can guide researchers, industries, authorities, and policy-makers in future sustainability efforts.

Keywords: *urban distribution, city logistics, logistics, sustainable, sustainability, environment, themes, initiatives, challenges*

1. INTRODUCTION

During the past century, the planet's urban population grew ten-fold. Now more than half of the world's population is living in urban areas. As a result of this rapid expansion, urban areas continue to grow at a faster rate than any other land-use type (Kinver, 2011). In Europe, approximately 80 percent of the citizens live in urban environment (McKinnon et al., 2010).
Due to urbanization: new infrastructures as well as buildings are built, jobs are created, diverse services are offered, and industrialization is advanced. Growth in urban areas has been a generator of economic growth as well. In Europe, 85 percent of the GDP (Gross Domestic Product) is generated in cities (EU, 2009).

Developments in urban areas are not tied with just good news. Evacuation of natural resources of the Earth like deforestation, shortage of land, and unequal distribution of power between rural and urban areas are just some cons to mention. Urbanization also increases mobility of humans and freights. Although economically and socially feasible, mobility in urban areas may lead to GHG emissions, local air pollution, energy/fuel consumption, congestion, accidents, noise, and visual intrusion. It has also negative effects on residents' health when they inhale GHGs and/or are injured by accidents and noise. Urban freight is also a large contributor to CO_2 emissions. It represents more than a quarter of the total CO_2 released by urban traffic; the fastest growing source of total CO_2 emissions in the urban environment (Dabland, 2008). In European Union (EU), transportation still depends on oil and oil products for 96% of its energy needs (EU, 2011). According to Eurostat (2011) transport's CO_2 emissions are constantly increasing and are the fastest-growing sector in Europe. In the same continent, urban transport is responsible for about a quarter of CO_2 emissions from transport, and 69% of road accidents occur in cities (EU, 2011).

In this regard, EU (2011, p.3) has set goals to limit climate change below $2^{o}C$ by drastically reduce GHG emissions – from all sectors of the economy – by 80-90% below 1990 levels until 2050. It is also estimated that a reduction of at least 60% of GHGs by 2050 with respect to 1990 is required from the transport sector. EU (2011, p.9) has also the goal to *"halve the use of 'conventionally-fuelled' cars in urban transport by 2030; phase them out in cities by 2050; and achieve essentially CO_2-free city logistics in major urban centres by 2030"*.

However, to achieve the EU's goals sounds tremendously challenging. It is clear that by current business as usual approaches, the goals cannot be reached (EU, 2011, p.4-5); instead new strategies with innovative solutions are required. Breaking the current approaches, ways of thinking, and patterns of behavior is fairly complex, costly, and time-consuming. Although innovation can be radical, adaptation of new solutions as well as change of behavior are just incremental (Rogers, 2003).

Complexity of freight- than passenger transport (Wigan and Southworth, 2004; Himanen et al., 2004; Lieb and Lieb, 2010) and, in specific, urban freight transport and distribution (McKinnon et al., 2010, p.294; Jönson and Tengström, 2005; Waddell et al., 2008) make their sustainable development challenging as well. One evidence of such complexity is large number of actors who influence freight distribution in urban/city areas such as Logistics Service Providers (LSPs), carriers, shippers/receivers (like retail stores, shops, restaurants, private consignees, and industries (construction industry, hotels, etc.)), residents, authorities, and researchers. Another dimension of such complexity is large number of activities which are/should be done in urban freight distribution operations. Some examples are consolidation, transshipment, coordination, sorting, kitting, sequencing, commercialization, packaging,

storage, handling, and transportation of freight as well as reverse logistical activities (recycling, repacking, refurbishing, waste handling, etc.).

In addition, freight- than passenger movements in urban areas is much more heterogeneous and dynamic. Freights are distributed through many (distribution) channels. Furthermore, the channels (including routs and paths) may change rapidly specifically in post- and home-delivery services. However, urban freight is more polluting than long distance freight transport as urban delivery vehicles are older on average, operating speeds are slower, constant acceleration and deceleration, and vehicle idling is frequent.

Due to such complexities, McKinnon et al. (2010, p.286) truly claim that "*the problems experienced by those performing freight transport and logistics operations in urban areas are far less well understood".* Until relatively recently, little attention has been paid to urban freight by researchers and policy makers (Dablanc, 2007; McKinnon et al., 2010; Álvarez and de la Calle, 2011). On the other hand, different initiatives that may lead to- or the challenges that may hinder sustainable urban freight distribution are lacking in the literature (Behrends, 2011; Abbasi, 2012). Although the studies by McKinnon et al. (2010), Patier and Browne (2010), Lindholm (2008), and Behrends (2011) found to be contributing for this sake, this study aims to take a more holistic view on current discussed initiatives (themes) and challenges. Such a holistic view is essential in order to: understand how different actors of the chain look upon sustainable urban freight distribution, avoid sub-optimal policies / governing rules, and suggest close-to-reality solutions for tackling the challenges.

The purpose of this article is to explore and classify the pattern of themes of initiatives and challenges in making urban freight distribution sustainable.

1.2 Demarcation

This study is demarcated to logistics in city/urban areas. All initiatives related to city logistics/urban freight distributions are in the scope of the study.
While the main focus of this study is on eco/environmental aspects of sustainability, due to the integrated nature of sustainable development, the integration of environmental issues with economic and social concerns have also been considered. In addition, phrases such as environmentally- sustainable / friendly / sound / preferable / responsible, eco, and green have been used synonymously.

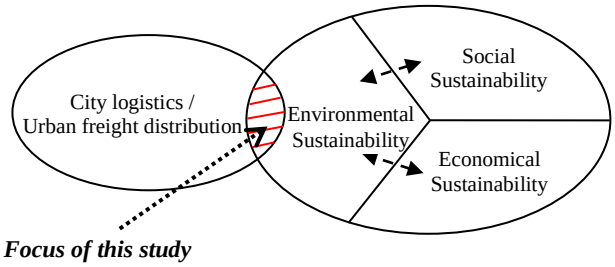

Figure 1 – Focus and demarcation of the study

2. FRAME OF REFERENCE

In 1987, a United Nations-sponsored report – published by Commission on Environment and Development (WCED) – entitled 'Our common future', also known as 'Brundtland Report', popularized the concept of 'sustainable development' and provided it with its widely known

definition: *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".* Following the United Nations 2005 World Summit, sustainable development encompasses the interdependent and mutually reinforcing pillars of economic development (Profit), social development (People) and environmental protection (Planet). The three pillars or 'P's of sustainable development are also called the 'three bottom lines' or 'triple bottom lines' (TBL or 3BL). Sustainable development is also referred by similar concepts such as 'corporate sustainability' (MacLean, 2010; Jeffers, 2010), 'corporate responsibility' (Zwetsloot, 2003), or just 'sustainability' (Aras and Crowther, 2009; Shrivastava, 1995). Environmental pillar of sustainable development is also labeled by phrases such as 'environmentally- sustainable / friendly / sound / preferable / responsible', 'eco', and 'green' (Björklund, 2005; Abbasi, 2012).

Urban freight distribution deals with logistics, mainly outbound, in urban areas. Urban, in contrast to rural, is usually referred to cities and towns. The combination of urban and rural areas is called metropolitan area. Urban freight distribution activities vary from delivery and collection of goods; goods- transport, storage, consolidation, and inventory management; waste handling; office and household removals; (Yamada and Taniguchi, 2006; McKinnon et al., 2010, pp. 282-302; Van Duin and Van Ham, 2001) to cooperation among freight stakeholders (Kawamura and Lu, 2006) and freight distribution policies (Marcucci and Danielis, 2008). Urban freight distribution may also be called by similar phrases like city logistics, urban freight logistics, urban logistics, and urban goods movement (Dablanc, 2007).
City logistics is an important process for totally optimizing the logistics and transport activities by private or municipal companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the framework of a market economy (Institute for City Logistics). Form Dablanc's perspective (2007), *"urban logistics can be defined as any service provision contributing to an optimized management of the movement of goods in cities"*. Alternatively, city logistics is involved in all the means over which freight distribution can take place in urban areas as well as the strategies that can improve its overall efficiency; such as mitigating congestion and environmental externalities.

3. METHODOLOGY

This study has a cross-sectional design. It entails collection of data from a variety of sources and at a single point in time (Bryman and Bell, 2007) in order to explore pattern of themes and challenges in making urban freight distribution sustainable.
The main method of data collection was literature review. During and after literature review, data were analyzed. Analysis was done by codification (open coding), classification, and synthesis of collected data based on principles of analytic induction. The results of the analyzed data (themes and challenges) are discussed in the next section. In the following subsections, methods of data collection and analysis are briefly explained (Table 1).

Table 1 – Methods- and sources of data collection and analysis in this study

		Source(s) of data
Methodology	***Literature review***	1) Peer reviewed journal and conference articles 2) Books and doctoral dissertations 3) Documents and reports from selected websites 4) Documents and reports from 'Øresund EcoMobility' project
	Analytic induction	Collected data from literature review

3.1 Literature review

The study began by collecting data by reviewing several mixes of literature from several sources. However, the literature review had a more narrative than systematic nature. According to Bryman and Bell (2007), the former one tends to be less focused and more wide-ranging in scope than the later one. Literature was selected from secondary sources and documents (Table 1); namely:

Peer reviewed journal and conference articles: In order to collect a purposeful sample (Patton, 2002, pp. 230) of articles, the online database at the library of Lund University in Sweden (LibHub) was selected. It includes sources such as electronic journals, E-print archives, JSTOR, IEE/IEEE standards and proceedings, and Proquest ABI database. At first, the LibHub database was searched by combination of selected keywords, namely (Urban freight*/City logistic* AND Sustain*/Environment*/Green). The search keywords had to be in title and/or abstract and/or keywords of the articles. This led to 470 available articles. Next, the abstract of all available articles were read. In some occasions, the introduction and conclusion sections of the articles were also read or whole of the article was skimmed.
The most relevant articles to purpose and scope of the study were then selected and registered in an Excel file. In total 61 articles (13% of the total available) were selected. The criteria for selection of the articles were that the discussed data shall have a thematic character (like managerial, educational), refer to an environmentally sustainable activity/issue (like developing environmentally friendly modes of transportation), or explicitly refer to a challenge/barrier. It is worth mentioning that some articles were appeared repetitively in one or several categories. In such cases, just one of them was counted. In addition, the articles/abstracts which were written in another language than English were not selected. The selected articles were then totally read by both authors.

Books and doctoral dissertations: Some hard copy or E- books and doctoral dissertations relevant to purpose of the study were read during the data collection and analysis phases.

Documents and reports from 'Øresund EcoMobility' project: This study was one part of the 'Øresund EcoMobility' research project (http://www.oresundecomobility.org/). All relevant publications, documents, and reports available on homepage or intranet of the project were read.

Documents and reports from selected websites: During the data collection phase, relevant documents and reports from two websites were also read. These websites are: 'European Commission-Mobility & Transport (http://ec.europa.eu/transport/index_en.htm)' and 'Europa-Gateway to the European Union (http://europa.eu/index_en.htm)'. These two were interesting for those financiers of the research project from European Union (European Regional Development Fund).

3.2 Analytic induction

Analytic induction (Bryman and Bell, 2007; Patton, 2002) was the main method for analysis of data in this study. The main reason to use this method was to allow the categories of themes and challenges emerge out of the collected data. This is very well in match with inductive reasoning of qualitative researchers. The principle was to seek universal explanation of categories of themes and challenges by pursuing the collection of data until no cases that were inconsistent with the emergent categories were found. On the other hand, collection of data was continued until theoretical saturation. This means that: successive literatures had

both formed the basis for the creation of a category - after open and focused coding (Charmaz, 2006) - and confirmed its importance; there was no need to continue with data collection in relation to that category or cluster of categories.
Worth to mention that '*code memos*' (Kvale and Brinkmann, 2009) were used during open and focused coding where the names of the different codes, who coded which parts of the material, the date when the coding was done, definitions of the codes used, and notes about the thoughts about the codes were recorded. The generations of codes were purely '*data driven*' than '*concept driven*'. Concept-driven coding uses codes that have been developed in advance by the researcher, either by looking at some of the material or by consulting existing literature in the field, whereas data-driven coding implies that the researcher starts out without codes, and develops them through reading of the material.

3.3 Judging research quality

In line with Bryman and Bell (2007)'s suggestions for evaluating qualitative research, two criteria were considered: *Trustworthiness* and *Authenticity*. Main measures to increase trustworthiness of the results were: transferability (generating representative samples of literature) and dependability (creating a research logbook/black box which entails complete records of every single phase of the research such as: problems formulation; selection of samples; literature reviews; coding schedule and manual; memos of open and focused coding; and data analysis procedures). In addition, analyses of collected data were done by both authors in order to decrease subjectivity in coding of data. On the other hand, in order to increase authenticity of the results, several mixes of literature from several sources were selected and the results were discussed among the research project's stakeholders.

4. RESULTS

Systematic review and analysis of the literature led to identification of the pattern of discussed themes and challenges. This section provides a classified synthesis of identified themes and challenges.

4.1 Identified themes

Eight themes were identified. The identified themes are explained here in detail.

4.1.1 Juridical and financial regulations/restrictions/limitations

Limitations and restriction are related to policies that aim to make freight distribution sustainable by regulating access to urban areas.

• ***Time restrictions – delivery timing – vehicle access time restrictions***

These regulations – usually called *access time windows* – aim to restrict the time of collection, delivery/loading and unloading of freight in urban areas. The most common form is *night deliveries* that may reduce noise pollution, traffic congestion, vehicles fuel consumption and as a result, GHG emission of freight distribution during the daytime (Bhuiyan et al., 2010; Álvarez and de la Calle, 2011; Munuzuri et al., 2005; Angheluta and Costea, 2011). According to Álvarez and de la Calle (2011), night deliveries have reduced the fuel consumption and CO_2 emissions by 15 to 20% in some European cities. Relaxation of access time windows and their harmonization among different municipalities can result in a relief of the environmental burden and a cost decrease for the retailers, too (Quak and de Koster, 2007).

• ***Vehicle load capacity restrictions – vehicle access weight /size/capacity restrictions***
Restrictions on vehicle access weight and size are some of the most common mobility policies and legislation. The goal is to restrict the entrance to urban areas of vehicles that surpass the specified gross weight, length, width, and height in urban areas. Such restrictions may lead to the reduction of congestion, pollution, intimidation, safety concerns, vibrations and noise in urban areas especially where pedestrians and other road users are present (Anderson et al., 2005; McKinnon et al., 2010). Another reason to introduce such restrictions is the limitations in infrastructures in urban areas such as height of bridges, width of carriageways, and dimensions of city squares.

• ***Environmental zones/low emission zones/clear zones***
Environmental zones – sometimes called low emission zones or clear zones – relate to geographical areas that can be entered by vehicles meeting certain emissions criteria/standards or below a certain age. The aim is to improve air quality in urban areas by encouraging the use of less polluting engine technologies (McKinnon et al., 2010) and more modern and cleaner vehicles (Anderson et al., 2005).

• ***Financial regulations/means***
There are also some financial means that can impact the environmental sustainability of urban freight distribution. The most common ones, reflected in the literature, are congestion charging (Awasthi et al., 2011; Hensher and Puckett, 2008; Goldman and Gorham, 2006), which is also called congestion pricing or road pricing. The aim is to reduce the number of vehicles that enter specific urban areas – especially where road and parking space are scarce – increase the average speed of vehicles – because of reduction in traffic intensity – and internalize the external costs originated by traffic congestion (Munuzuri et al., 2005; Anderson et al., 2005). Toll systems (Angheluta and Costea, 2011) and taxes on vehicles are other mechanisms for reducing traffic intensity and congestion in urban areas.

4.1.2 Structural and Infrastructural
These relate to initiatives that aim to make urban freight distribution sustainable by restructuring the supply chain design or maximizing the capacity utilization of existing infrastructures.

• ***Urban Consolidation Center (UCC)***
The goal of UCC initiatives is to consolidate the freight flows from outside the city before delivery in urban areas. This will help to bundle inner-city transportation activities (Yamada and Taniguchi, 2006; van Rooijen and Quak, 2008). Browne et al. (2005) consider a wider goal of UCC by stating that *"UCC is best described as a logistics facility that is situated in relatively close proximity to the geographic area that it serves, be that a city center, an entire town or a specific site (e.g. shopping center), from which consolidated deliveries are carried out within that area".* UCCs are also called by similar phrases (Browne et al., 2005) like urban shared use freight terminals (Dablanc, 2007), city terminals (Munuzuri et al., 2005), city distribution centers (van Rooijen and Quak, 2008), and urban freight consolidation centers (Edoardo and Danielis, 2008).

The main advantage of UCCs is reduction of traffic intensity (total number of operating vehicles) in urban areas by improving the load factor and empty running of vehicles. However, it might take more small vehicles to replace the large vehicles, which could increase the number of vehicles in the city (van Rooijen and Quak, 2008). Such initiatives can also reduce- fuel/energy consumption per ton-km, vehicle emissions and noise generation in

delivering goods as well as making the area more pedestrian-friendly (Browne et al., 2005; Álvarez and de la Calle, 2011; Weber, 2003;). According to Goldman and Gorham (2006), such initiatives have reduced number of truck trips into the city and truck operating times by 70% and 48%, respectively in some German cities.

- ***Maximizing capacity utilization of existing infrastructures***

Some literature sheds light on initiatives that aim to maximize the capacity utilization of existing roads, parking places, load/unloading areas, and pedestrian/bicycle ways. "Multi-use lanes", common use of "public and private parking lots"– mainly used for passenger vehicles – or "other reserved spaces" (taxi zones, bus lanes, motorcycle parking spaces, and parking spaces for disabled people) during certain time intervals are some of these initiatives that adapt the use of public roads and spaces to the different freight distribution operational needs emerging during the day.

"Load zone provision", "delivery zones", and "dynamic allocation of loading and unloading places" – reserved spaces to be used by delivery vehicles for loading or unloading freight in certain dense urban areas – as well as "temporal individual load spaces" and "short time double parking" (Munuzuri et al., 2005; Álvarez and de la Calle, 2011; Awasthi et al., 2011) are other initiatives worth mentioning. Although these initiatives may not reduce the number of vehicles during peak hours, they can reduce traffic intensity and congestion by facilitating parking, and loading/unloading operations.

- ***Underground urban goods distribution***

The aim of underground urban goods distribution initiatives is to utilize the underground links or network for distribution of goods among distribution centers around urban areas and receivers (like shops) inside the urban areas. According to Binsbergen and Bovy (2000), the concept of underground goods transportation has potential feasibility for urban distribution of food products and consumer goods. It can also reduce noise levels, improve local air pollution, and decrease energy use for propulsion.

4.1.3 Managerial

Managerial issues are related to activities that can contribute to the sustainability of urban freight distribution such as planning, control, measurement, monitoring, modeling, assessment/evaluation, cooperation/coordination/collaboration, and partnership.

Modeling activities are reflected on in several articles. These range from multi-criteria decision-making approaches for location planning for urban distribution centers under uncertainty (Awasthi et al., 2011) to peak-hour urban freight movements with limited data availability (Munuzuri et al., 2010), and CO_2 emissions for different levels of congestion and time-definitive customer demands (Figliozzi, 2011). Modeling can also be found in Gao and Sheng (2008) who take advantage of simulation methods combined with improved heuristic algorithms to solve the dynamic vehicle routing problem with time windows (DVRPTW) in real city environments.

Evaluating activities can be found in Awasthi and Chauhan (2012) who present a hybrid approach for evaluating four city logistics initiatives: vehicle sizing restrictions, congestion charging schemes, urban distribution centers and access timing restrictions. Hensher and Puckett (2008) present a choice-modeling framework for *assessing* the influence of distance-based charges on freight transporters. Route *planning* of delivery fleets (Zeimpekis et al., 2008) and *mapping out* the pattern of goods distribution (Ljungberg and Gebresenbet, 2004)

in order to reduce costs, congestion, and environmental impact are other activities of a managerial thematic character.

Cooperation, coordination, and *collaboration* are inseparable activities of sustainable logistics and supply chains. Urban freight distribution is not an exemption. *Partnership* between public and private sectors (McKinnon et al., 2010), inter-organizational cooperation among actors and stakeholders involved in city logistics (Petersen, 2006), cooperation in distribution channels, and coordinated goods flows are just a few examples of managerial activities.

4.1.4 Environmentally friendly modes of transportation

These initiatives relate to design and production of new green modes of transportation as well as taking advantage of inter- and co-modalities.

- ***Inter- and co-modality***

Transferring freight from urban roads to rail and marine (Dinwoodie, 2006; Pawlak and Stajniak, 2011; Goldman and Gorham, 2006) – which may have less energy intensity per ton-km – are among the discussed activities in making urban freight distribution sustainable. Co-modality, by combining different modes together, like cargo- trams and ferries combined with electric powered trucks (Angheluta and Costea, 2011), freight busses and metro (Petersen, 2006; Amico et al., 2011), and passenger and cargo trams (Munuzuri et al., 2005) are some other initiatives. Inter- and co-modality by shifting to non-road modes of transport can reduce congestion on roads as well as costs of distribution operations.

- ***Developing environmentally friendly vehicles***

Designing, developing, and producing more environmentally friendly vehicles – with less energy and emission intensity – are inseparable parts of zero emission and eco-mobility strategies. Using electric vehicles (Álvarez and de la Calle, 2011) like electric lorries and vans (Zuccotti et al., 2011; Binsbergen and Bovy, 2000), zero emission vehicles powered by hydrogen (Rambaldi and Santiangeli, 2011), and gas and electricity powered trucks (Angheluta and Costea, 2011) can all contribute to environmentally friendly city distribution operations.

4.1.5 Technological developments

Developing clean/green/environmental technologies are permanent strategies towards sustainable development of city logistics, logistics, and supply chains. Several articles shed light on ICT as enablers of green urban freight distribution. They are also some major enablers of world-class infrastructure (Toh et al., 2009). Such technologies are also keys to integrated, connected, visible, adaptive, and intelligent supply chains. ICT can be found in today and in the future of sustainable urban freight distribution to track and trace goods and resources of supply chains and take advantage of Global Positioning Systems (GPS), route optimization, variable message panels, traffic management systems, identification tags, smart cards, computer software and hardware, emission calculators, parking monitoring tools, on-line load zone reservations (Gebresenbet et al., 2011; Zuccotti et al., 2011; Qiang and Miao, 2003; Munuzuri et al., 2005). According to Weber (2003), *"Bottom-up processes of strategic niche management with new emerging technologies have the potential to trigger regime shift towards a more sustainable supply of energy and transport services."*

4.1.6 Emissions and Fuels economy

Developing sustainable fuels with zero emissions and without antagonistic effects somewhere else, like destroying food resources or high costs, improving engine efficiency, and

controlling measures towards reduction of emissions, are long-term trends that can reduce energy and emission intensities of freight distribution in urban areas. Among the related reviewed literature, Yoshizumi et al. (1982) have studied diesel emission levels of several urban driving cycles and analyzed the effects of average speed on emissions and fuel economy by diesel trucks. Another example is Gebresenbet et al. (2011) who have studied emission estimation for an urban food delivery system.

4.1.7 Distribution services

Distribution services are complementary to sustainable physical freight distribution. Some exemplary services which can reduce transport intensity, traffic intensity as well as congestion and emissions in urban areas are: home service distribution (Álvarez and de la Calle, 2011), neighborhood drop-off points (Goldman and Gorham, 2006), use of packaging automates in the distribution process (Pawlak and Stajniak, 2011), DHL pack stations and BentoBox (Amico et al., 2011).

4.1.8 Educational

Education and change of behavior are building blocks of making and developing sustainable supply chains. Education plays an important role in informing the human resources of dimensions of sustainability as well as improving their performances.

4.2 Identified challenges

Seven challenges were identified and classified and are explained in the following sub-sections.

4.2.1 Decoupling

Economic growth both effects and is effected by freight distribution and transport growth. Traditionally, goods transport increases with growth in the GNP (Taniguchi and Van Der Heijden, 2000). In many urbanized European regions, the pace of growth in goods transport is about twice that of the GNP (Binsbergen and Bovy, 2000). The challenge is to decouple economic growth from an increase in urban freight mobility and environmental damage/degradation. As Afroz et al. (2011) reflect, the challenge is to develop collaborative business models to *"meet the future challenges of the growth of trade, freight movement and maintaining economic, environmental and urban sustainability."* To achieve the EU targets (EU, 2011) is very challenging as the emissions should drastically reduce by 2020 and 2050 while the number of vehicles (Gebresenbet et al., 2011) and the population are increasing.

4.2.2 Restructuring

Dynamic restructuring of patterns of urban freight distribution has made its sustainable development challenging, too. For example, the growth of e-business/e-commerce, home deliveries, and just-in-time (JIT) trends have drastically changed the B2C (business to consumers) as well as B2B (business to business) transactions by having antagonistic effects on the environment and sustainability (see for example Abukhader, 2005 and McKinnon et al., 2010). The scenario becomes even more challenging when freight distribution in urban areas is influenced by global supply chains/networks. As Markus (2006) discusses, both "global change" and "global chain" may lead to "local pain". (…) "*Increasing globalization and global economic integration exert constant pressure on local places to adapt to these processes."*

Adaptation to these changes and reconfiguration of freight distribution may also lead to further challenges in urban areas where the infrastructures, spaces, and resources are limited;

roads and streets are narrow and compact (especially in historic and central parts of cities) (Gonzalez-Feliu and Morana, 2011; Pawlak and Stajniak, 2011; Goldman and Gorham, 2006).

4.2.3 Costs/Financial viability

A major challenge in making urban freight distribution sustainable is cost. In general, in the same time period, the average costs of freight distribution in urban areas (short distance) is higher than inter-city (long distance) freight distribution. The reasons are higher fuel consumption of vehicles due to more congestion and less average speed as well as more stops and load/unload operations in urban areas.

Corporate social responsibility – including both environmentally and socially sustainable – initiatives, activities, and strategies that may threaten economical sustainability are less likely to be continued. This is a real challenge, as many of these may be very costly, at least initially. For example, although environmentally beneficial, adding urban consolidation centers/terminals/cross-docks can result in potentially high set-up and operating costs. There is also an increase in delivery costs because of the additional stage in supply chains, potential costs associated with additional companies handling goods, and increased transaction costs (Browne et al., 2005; Dablanc, 2007; Quak and de Koster, 2007; Marcucci and Danielis, 2008; McKinnon et al., 2010; Álvarez and de la Calle, 2011).

High investment costs in developing, constructing, or restructuring the infrastructure is also a challenge. For example, it is costly to build and maintain new (cargo) tramlines, underground distribution links, new fuel stations, dry ports, hubs, and intermodal terminals. It is also costly to shift the fleet to more environmentally friendly ones and develop new fossil-free fuels as well as clean/green/environmental technologies (EU, 2011; Binsbergen and Bovy, 2000; Angheluta and Costea, 2011).

4.2.4 Operationalization

Several factors make sustainable urban freight distribution operationally challenging. One is the considerable lack of knowledge and understanding of the nature of city logistics and initiatives/themes. The problems caused by freight transport and distribution in urban areas are far less well understood (Browne et al., 2005; McKinnon et al., 2010, p. 286). A comprehensive evaluation and evidence-based information of full financial, environmental, and social impacts of city logistics initiatives is lacking in the literature, too.

Another factor is the reluctance of city logistics stakeholders to accept or participate in initiatives. For example, night deliveries where the receiver must be present when the delivery is made are not always acceptable (Munuzuri, et al., 2005). There are also concerns about higher driver wages, higher reception/dispatch costs, and safety when it comes to night deliveries (Anderson et al., 2005). Another common example is the construction and operations of a UCC initiative that may be ultimately doomed to fail if those who are the potential customers refuse to participate. There are some evidence-based studies attesting that businesses with frequent, differentiated, and high-volume deliveries are less willing to use UCC services (Marcucci and Danielis, 2008) where much of the urban freight is already consolidated at the intra-company level or by parcels carriers (Browne et al., 2005; McKinnon et al., 2010). In most of such businesses, the vehicles are already fully loaded. In addition, businesses dealing with valuable goods (van Rooijen and Quak, 2008) as well as bars, restaurants, and hotels – which demand higher frequency, punctuality, and logistics quality – (Marcucci and Danielis, 2008) are more reluctant to participate. McKinnon et al. (2010) also elaborate on difficulties that may emerge for a single UCC as it may be unable to handle the

wide range of goods moving in and out of an urban area, due to such factors as different handling and storage requirements. Browne et al. (2005) add that: *"A single consolidation center for an urban area is unlikely to be attractive for many suppliers' flows due to the degree of diversion required from normal route (and may therefore negate transport savings for onward distribution)."* Obligation and compulsion can also threaten the sustainability of UCCs by making the potential customers as well as private sector unwilling to participate and/or pay (McKinnon et al., 2010).

Inefficiency in urban freight distribution is another factor that can make the operationalization of sustainable development challenging. It is fairly challenging to improve the efficiency of urban mobility while ensuring environmental quality and economic growth as well as maintaining livable communities (Figliozzi, 2011; Gebresenbet et al., 2011). Inefficiencies in urban freight transport can occur as a result of existing road layouts or traffic levels, unintended consequences of non-freight urban transport policies on freight transport operations (e.g. the introduction of bus lanes), variations in urban freight transport policy measures in different urban areas or different parts of a single urban area (McKinnon et al., 2010), and counterproductive institutional roles and procedures (Jönson och Tengström, 2005).

4.2.5 Uncertainties

Another challenge is related to uncertainties inherited in different aspects of urban freight distribution and sustainability. There are several strategic uncertainties regarding production capacities and logistics of new fossil-free fuels, design/location and capacity planning/viability of supply chain static resources (like distribution centers, UCCs, terminals, facilities) in urban areas, construction of new infrastructures, behavioral effects of congestion charging regimes, etc. (Angheluta and Costea, 2011; Marcucci and Danielis, 2008; Hensher and Puckett, 2008; Awasthi et al., 2011).

There are also operational uncertainties due to unexpected/unforeseen incidents like order cancellation, delivery time changes, new customer requests, traffic congestion, road construction, flea markets, natural disasters, weather changes, accidents, and mechanical failures (adapted from Zeimpekis et al., 2008). Other uncertainties are due to the psychological reluctance of customers to buy clean technologies, as they might not be fully convinced of their practicability and chance of survival on the market (Angheluta and Costea, 2011).

Finally, yet importantly, there are uncertainties, dilemmas, and misunderstandings regarding paradoxical/contradictory/antagonistic effects of freight distribution activities/initiatives in urban areas. For example, "Lean" and "just-in-time" (JIT) may increase service levels and efficiency of freight distribution while at the same time leading to small order problems and increased less-than-truckload (LTL), empty running, costs, congestion, fuel consumption, and GHG emissions (Gebresenbet et al., 2011; McKinnon et al., 2010). There are also dilemmas in decision making for the facility location of static resources. For example, locating distribution centers close to customers' locations may increase traffic congestion in urban areas while locating far from them may increase costs of transportation or destroy green fields (Awasthi et al., 2011; Toh et al., 2009).

4.2.6 Lack of visionary leadership

Today, there is a lack of visionary leadership in making urban freight distribution sustainable as visions and goals are vague, short-term market perspectives are in focus, and potential long-term benefits of initiatives and legislation are misunderstood (Petersen, 2006; Angheluta

and Costea, 2011). This is a real challenge in the construction and development of infrastructures as they last for several decades; it takes many years to plan, build and equip them, and considerable investment will be needed (EU, 2011).

In addition, there are tremendous difficulties in creating a new and innovative urban mobility culture that all stakeholders accept and follow the legislation and initiatives (Zuccotti et al., 2011; Pawlak and Stajniak, 2011). To change and shift the organizational culture is also tied to behavioral challenges, as there is a very high inertia and resistance to change. Sustainable development brings significant challenges to traditional business models – which have a clear focus on financial aspects only – and the ways that different stakeholders define their missions and strategies, and organize their work and operations (Jönson and Tengström, 2005; Goldman and Gorham, 2006; Weber, 2003; Browne et al., 2005).

4.2.7 Corporate governance

Another challenge is related to corporate governance of freight distribution in urban areas. For example, there are bureaucratic difficulties (Jönson and Tengström, 2005) and administration barriers (Angheluta and costea, 2011) embedded in decision making where several actors at different levels, from municipality and regional to state levels, influence urban distribution. Other dimensions of the difficulty of corporate governance of urban freight distribution are variations in urban freight transport policy measures in different urban areas or different parts of a single urban area (McKinnon et al., 2010; Anderson et al., 2005), governmental policies (Quak and Tavasszy, 2011) and rules (Dablanc, 2007) related to zoning, emissions, vehicle restrictions, and access conditions to roads and terminals. The scenario becomes even more complex when it comes to the development of sustainable and integrated/united continental or global governing bureaucracies and measures (EU, 2011).

In an analysis of barriers to urban transport sustainability, Jönson and Tengström (2005, p. 222) highlight the lack of political commitment and national policy framework: *"When the political will is lacking, the problems can be recognized, but are not deemed enough – in practice – for there to be a real change in the system in place."* On the other hand, Dablanc (2007) elaborates on local policies and similarly concludes that in major European cities, local public policies regarding freight are scarce and out-of-date: *"Because of the impacts of freight on the urban environment, local governments are aware that they should control goods transport activities, but most do not know how" (...) "For most cities, existing freight policies do not appear to measure up to the important changes which have taken place in the production, distribution and consumption sectors."*

Other challenges raised in the literature are: Poor policy integration and co-ordination, unsupportive legal or regulatory framework/ policy measures, wavering political commitment (Jönson and Tengström, 2005; van Rooijen and Quak, 2008); potential to create monopolistic situations, thus eliminating competition and perhaps leading to legal issues (Browne et al. 2005; Toh et al., 2009); and unwillingness to collaboration among producers or between large-scale and small-scale transport companies and uncertainties regarding who takes the initiative (Weber, 2003; Gebresenbet et al., 2011).

5. CONCLUDING DISCUSSION

As it is clear from the identified themes, urban freight distribution cannot become sustainable with just one activity or theme of activities. Instead, a packet of themes of activities and mixed strategies with minimal antagonistic effects on each other is required. The identified

themes may help the readers to have a more holistic view on the main activities discussed in literature. Taking a holistic view while development sustainable urban freight distribution is essential in order to understand economic, environmental, and social effects of identified themes on each other and avoid sub-optimal, irrationalized, and based on intuition discussion and decision making. Taking short-term perspective and/or considering urban freight distribution in isolation from their supply chains or other aspects of urbanization will not make them sustainable. It is also important to realize that 'one shoe does not fit all'. The packet of activities and strategies should also be adaptive as each urban area is unique. Differences among shape, size, nature, and society of urban areas have led to different types of freight distribution inside them. The urban freight distribution needs to be adjusted to the local context and user requirements as well as regulations and policies of a specific city (Gebresenbet et al., 2011). It should also be adaptive to new clean technologies and infrastructures.

5.1 Recommendation for tackling the challenges

In order to tackle the challenges, it is recommended that the complexity of such a complex socio-technical system (urban freight distribution) be harnessed, visionary leadership for transformation of this system towards sustainability be appreciated, and both top-down and bottom-up changes be considered.

Harness the complexity

Urban freight distribution is a complex socio-technical system with tremendous number of interconnected actors/stakeholders and activities which influence its sustainable development. In order to harness this complexity, these actors and activities shall be identified and classified, and their effects on sustainability of urban areas/cities (environmental protection, livable human societies, and economic profitability) shall be managed. In addition, effects of current and future business and market trends on urban freight distribution must be fully investigated. For example, the role of: globalization in distribution industries - and, vice versa, the significance of distribution in globalization – (Markus, 2006), future of ICT (Information and Communication Technologies), and clean technologies deserve full investigation.

Visionary leadership

Urban freight distribution calls for charismatic visionary leaders who may transform it towards sustainability and develop it sustainably. It is also necessary to shape a new culture of sustainable mobility among all the stakeholders where big and innovative ideas be heard, developed, and evolved. Education, information, and innovation are important factors for creation of such culture.

Top-down and bottom-up changes

Both top-down and bottom-up strategies and initiatives should be considered for transformation of complex city logistics towards sustainability. Governmental subsidies, funding, and liberalized policies and restriction are some examples of top-down ones. On the other hand, some bottom-up examples are: collaboration of local stakeholders and practitioners (like retailers, transport operators, shippers, and residents) by taking part in initiatives as well putting pressure on local and central government. Combination of bottom-up initiatives with top-down legislation may increase the chance of acceptance and operationalization of all pillars of sustainable development.

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Appendix

“Interview guide of the research study 2 (RS2)”

Interviewers: Maisam Abbasi and Fredrik Nilsson

1.1. Information collection during the interviews

Background Information

Gender:

Years of experience:

Department:

Position:

Main tasks / functional job:

1.1.1. Current sustainability- related issues

The aim of this section is to:

- Define aspects of sustainable development from interviewees' perspective;
- Diagnose 3PL's sustainability-related operations & activities;
- Analyze operations of 3PL's supply chains.

1) How do you deal with/define sustainable development? *[In this case, the interviewers and interviewees can match their definitions, perceptions, etc. – Lead to delete of misunderstanding]*

2) How do you deal with/define sustainable development for a TPL/ goods transport sector? *[Finding themes of sustainable development for goods transport industry]*

3) Supply chain related questions: *Actors that they collaborate with, modes of transport that they use, information about 'fill-rate' and 'resources utilization'*

1.1.2. Future sustainability- related issues (Till 2020 & 2050)

The aim of this section is to:

- Diagnose and analyze 3PL's <u>future</u> sustainability-related strategies, operations & activities;

1) What have they planned/ what strategies do they have for sustainable development till 2020 & 2050? *[Ask if they have shorter or longer vision than 2020]*

1.1.3. Challenges of sustainable developing

The aim of this section is to:

- Diagnose current as well as probable future challenges for sustainable development;
- Diagnose remedies for challenges.

1) What were the difficulties, barriers … for sustainable development till today?

2) What difficulties, barriers… do you predict/expect till 2020 & 2050? *[Ask if they have shorter or longer vision than 2020]*

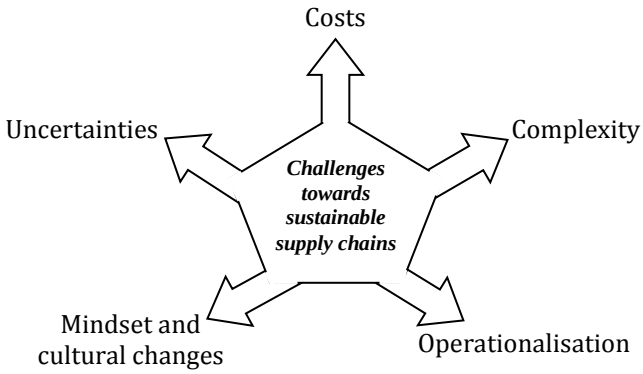
3) What do you suggest for mitigation/elimination of challenges?

1.1.4. Complementary questions / survey

The aim of this section is to:

- Compare theoretical findings of first article with what happens in reality/practice.

Results of a comprehensive literature review on 'challenges of developing sustainable supply chains' revealed five main categories of challenges, namely: *Costs, Complexity, Operationalisation, Mindset & Cultural changes, and Uncertainties.* How do you assess relevance of these challenges for your organization?



A. <u>Costs</u>

A.1. To develop and carry on logistical solutions where sustainability is prioritized cost _____ than development of those solutions where sustainability is less prioritized.

1	2	3	4	5
Much less		Same		Much more

A.2. Quantifying environmental costs of operations/ processes/ activities are:

1	2	3	4	5
Very easy				Very difficult

A.3. It must financially pay to be green:

1	2	3	4	5
Not important				Very important

B. Complexity

B.1. Diagnose of environmental aspects / effects of logistical operations/ processes/ activities are:

1	2	3	4	5
Not difficult				Very difficult

B.2. Diagnose of social aspects / effects of logistical operations/ processes/ activities are:

1	2	3	4	5
Not difficult				Very difficult

B.3. Measurement/assessment of environmental effects of logistical operations/ processes/ activities is:

1	2	3	4	5
Not difficult				Very difficult

B.4. Measurement/assessment of social effects of logistical operations/ processes/ activities is:

1	2	3	4	5
Not difficult				Very difficult

B.5. There are *paradoxes* in sustainable development *(e.g. making one part sustainable may make another part unsustainable!)*

1	2	3	4	5
Not agree				Fully agree

Example of paradoxes: ….

C. Operationalization

C.1. *Interpretation* of dimensions of sustainable development (triple bottom lines) in logistical operations/ processes/ activities is:

1	2	3	4	5
Not difficult				Very difficult

C.2. *Inertia* (resistance to change) in the organization to development of environmentally-sustainable operations/ processes/ activities is:

1	2	3	4	5
Very low				Very high

C.3. *Inertia* (resistance to change) in the organization to development of socially- sustainable operations/ processes/ activities is:

1	2	3	4	5
Very low				Very high

D. Mindset & Cultural Changes

D.1. Making *customers* aware of dimensions of sustainable development are:

1	2	3	4	5
Not difficult				Very difficult

D.2. Change of *customers*' behavior / mindset is:

1	2	3	4	5
Not difficult				Very difficult

D.3. Making *decision-makers* aware of dimensions of sustainable development are:

1	2	3	4	5
Not difficult				Very difficult

D.4. Change of *decision-makers*' behavior / mindset are:

1	2	3	4	5
Not difficult				Very difficult

D.5. Making *co-workers* aware of dimensions of sustainable development are:

1	2	3	4	5
Not difficult				Very difficult

D.6. Change of *co-workers*' behavior / mindset are:

1	2	3	4	5
Not difficult				Very difficult

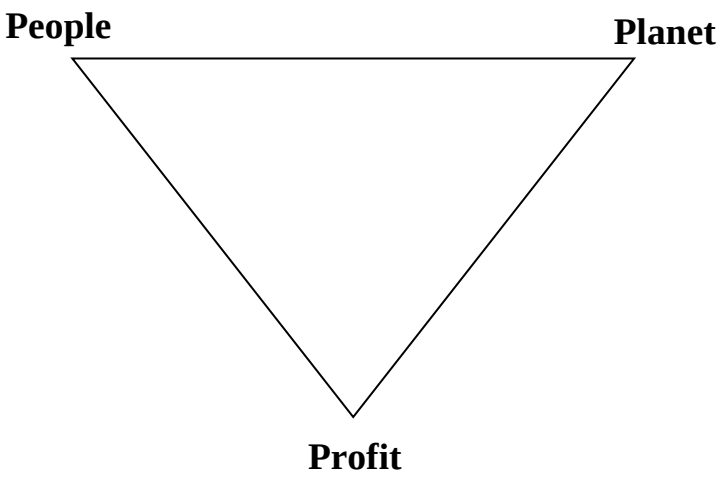
E. Uncertainties

E.1. Uncertainties to the degree & nature of governmental regulations & policies are:

1	2	3	4	5
Very low				Very high

E.2. Uncertainty in long-term development is:

1	2	3	4	5
Not challenging				Very challenging

Appendix

Where does the work of your organization regarding *sustainable development* fit in the picture below?