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## Multi-Donor Trust Fund for Sustainable Logistics (MDTF-SL)

### Position Note on Green Logistics (Supply Chains)



The Multi-Donor Trust Fund for Sustainable Logistics (MDTF-SL) commissioned a series of short notes from recognized thought leaders to better understand burgeoning issues within the MDTF-SL's thematic pillars. This note explores issues within the Green Logistics / Supply Chains thematic pillar and was prepared by Prof Dr Ir Jan C Fransoo from Eindhoven University of Technology, The Netherlands.

The Green Logistics pillar is one of three focus areas, or thematic pillars, for the MDTF-SL. The goal of this pillar is to support activities in low income and developing countries that contribute to the development of transport corridors and logistics services, while minimizing the carbon footprint and greenhouse gases associated with the delivery of goods.

By allowing for trade patterns and product value chains to be built sustainably, the "greening" of supply chains can improve the competitive positioning of developing country exports, particularly in industries and production value-chains monitored for their carbon footprints.



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# GREEN LOGISTICS: ENABLERS FOR SUSTAINABLE DEVELOPMENT<sup>1</sup>

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<sup>1</sup> This paper is based on literal text excerpts from a draft working paper titled: “Green Logistics: Sustainable Supply Chain and Enabling Policies”, authored by Jan C. Fransoo and Yann Bouchery (Eindhoven University of Technology), Jean-Francois Arvis (World Bank) and Lauri Ojala (University of Turku).



## 1. INTRODUCTION

Logistics is the backbone of industry and commerce. As a discipline, it describes the management and coordination of activities along supply chains. These activities include freight transport, storage, inventory management, materials handling and related information processing. A large part of logistics activities are often outsourced to specialized providers that provide cost-effective services. Research has shown that, at least in high income economies, the value of services is not assessed in monetary and service quality terms alone. In making decisions, logistics professionals are increasingly taking into consideration external effects such as emissions, pollution, noise, and accidents.

The last LPI report release in 2012, for instance, pointed out that in shipments to OECD countries, environmentally friendly solutions are considered far more often than elsewhere. Mounting regulatory pressure, together with changes in customer preferences, are the main drivers of this phenomenon. One of the more widely used terms to describe this set of preferences is “Green Logistics,” especially when the activities of logistics service providers are concerned.

Research, including a recent book by Alan McKinnon, has established that “Green Logistics” is an emerging concern of private operators and providers and users of logistics. From a policy standpoint, and especially for the global environment, “Green Logistics” is potentially a major topic as well: estimates vary, but about 15% of global greenhouse gas emissions (GHG) can be traced to logistics activities.

“Green Logistics” may not be an independent policy area. Rather, the supply chain perspective provides a framework to understand and deal with issues that are separate but ultimately interrelated. Importantly, looking at supply chains helps policy makers understand the interests and actions of private sector operators. “Green Logistics” may therefore propose a number of tools and identify emerging sustainable solutions contributing to the overarching objective of “Green Growth.”

From a policy perspective, logistics cut across several areas and sectors. The performance of supply chains depends on areas or activities where government as regulator or catalyst of investment is critical, such as:

- Transport infrastructure: road and rail corridors, ports and airports



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- The efficiencies of logistics services: services include not only modal freight transport, but also warehousing and intermediary services, such as brokers and forwarders, and related information-flow management. In modern economies, the trend is towards integration in multi-activity logistics providers (3PLs, 4PLs) to which industrial and commercial firms outsource their supply chain activities. Understanding the regulatory dimension of services is becoming increasingly critical to the development of effective policies in areas such as: professional and operational standards, regulation of entry in market and professions, competition, enforcement...
- Procedures applying to the merchandise, such as trade procedures (customs and other controls).
- The soft infrastructure that supports information or financial flow associated with the physical movements along supply chains: IT infrastructure, payment systems...

The concept of national logistics performance – capturing the outcome of these policies – is widely recognized by policy makers and the private sector worldwide as a critical contribution to national competitiveness. A key question for sustainable development is how to integrate supply chain participants' concern with environmental sustainability with the concept of national logistics performance.

Within logistics, transport creates the largest environmental footprint. But the volume of emissions can vary greatly, depending on the mode of transport. The volume of emission per ton per km increases by an order of magnitude from maritime to land transportation and to air transportation. This is a key environmental aspect of logistics that is not taken into consideration by most supply chain operators. Logistics experts typically integrate freight modes and other related activities so that the transport and distribution network is used in the most efficient manner, which is important for keeping emissions in check, as well. Depending on the type of industry and geographical region, supply chain operators can place varying emphasis on the reliability of supply chains, as well. In summary, supply chain choices typically include multiple criteria and trade-offs, and this makes an analysis of their environmental impact complex; the most environmentally friendly choices do not only depend on mode of transportation, but also on other elements, such as efficiency and reliability.

To reduce the environmental footprint of a supply chain, the focus should be on several dimensions and should select the best mode of transport, efficient movements, and innovation. Comprehensive work on “greening” individual modes of transportation is already available. Here, the key drivers have been energy efficiency and the urge to diminish various types of



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emission. Given the integrated nature of supply chains, however, the manner in which price signals and incentives catalyze supply chain structure is a rather intricate problem: lower-emission modes of transport (maritime, e.g.) are typically also less reliable or have other limitations (such as maritime access to a landlocked country). Such limitations may include the cost of such technologies, the temperature range within which they can be used or the availability of certain types of fuel. It is therefore critical to complement the current knowledge about emissions produced by different modes of transportation with an understanding of what drives the demand for “Green Logistics” within supply chains.

The emerging response is likely to take the form of top-down policy, such as measures in the form of standards or taxes addressing emissions (GHG, SO<sub>2</sub>, NO<sub>x</sub>) by mode of freight. For instance, a cap on SO<sub>2</sub> emissions on major maritime routes will go into effect at the end of 2015<sup>2</sup>. At least as important is the response from the bottom up. These are supply-chain strategies coming from the private sector in response to policy or price changes, but also demand from consumers, clients and stake-holders. Green Supply Chain management has to be taken seriously by policy makers.

An exclusive focus on price mechanism (including taxes), as is the current tendency, may miss some of the major driver of changes in supply chain management. Another complication, at least in the context of international trade, is that the focus on the impact on international logistics does not capture the footprint of production processes. These processes may have different impact than the supply chain itself, as in the case of food production.

There is also evidence that much of the environmental footprint of logistics operations is tied to short distances and distribution. “Green Logistics” is intimately linked with concerns such as urban congestion, and innovations in “City Logistics” are critical to sustainable supply chains. Grassroots innovations in “City Logistics” have recently flourished, often producing win-win solutions in terms of jobs and the environment. More generally, there is increasing awareness that green supply chains can be also competitive, either because the awareness of the environment helps productivity or because consumers expect it, particularly in wealthy countries.

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<sup>2</sup> A concrete case in point is also the so-called sulphur emission regulation by IMO that enters into force on January 1, 2015 in most of North Sea, Baltic Sea and along west and east coasts of US & Canada (bar Alaska). Ships have to go over from fuel with 1.5 % sulphur to 0.1 % sulphur – or invest in so-called scrubbers, that absorb the sulphur from exhaust gases; technology that is still nascent in the maritime context. Scrubber investment per cargo ship is USD 2 million and up with multiples as the ship engine size increases, with annual maintenance cost approx.. 7-10 % of investment. This seemingly innocent and rather technical change is going to have a huge impact on shipping and the spillover effect to other modes & Supply chains are going to be significant...



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“Green Logistics” also encompasses potentially longer-term concerns. A green focus within logistics analysis could examine a supply chain’s vulnerability to climate events or to large swings in the price of transport inputs, for instance. A recent volcanic episode in Iceland showed the vulnerability of one specific supply chain that relies heavily on air freight – fresh produce coming from Africa spoiled when flights were cancelled because of the volcanic ash. Resilience concerns and other form of uncertainty are likely to shape supply chain choices by regional and global operators. Given the importance of trade in components and intra-firm trade, how large operators develop green supply chain strategies will have profound economic impact. Resilient and greener supply chains are likely to be less extended and leaner, for example, though the consequences for trade and integration of low income economies cannot be treated fully here.

Policy makers should be concerned by both the supply and demand aspects of logistics’ environmental dimensions. So far, the policy focus has been on modal footprint and has not taken into account a supply chain perspective. There have not been major initiatives in “Green Logistics,” even in the countries most sensitive to the issue, such as those in Northern Europe. Rather the most important changes have occurred as a combination of largely uncoordinated public and private initiatives: voluntary behavior by shippers, innovation in terms of technology, information (environmental logistics dashboard) or services, or common public-private objectives such as in modal shifts.



## 2. DEFINING GREEN LOGISTICS AND GREEN SUPPLY CHAIN MANAGEMENT

There are many variations in the terminology regarding green logistics and green supply chain management. This section aims at providing a brief overview on some of the key terms used in the literature.

*Green logistics* refers mainly to environmental issues related to transportation, material handling and storage, inventory control, warehousing, packaging, and facility location allocation decisions (Min & Kim, 2012). Gonzalez-Benito and Gonzalez-Benito (2006) use the term *environmental logistics* to describe logistics practices that are divided into supply/purchasing, transportation, warehousing and distribution, and reverse logistics and waste management. Although distribution is considered to be one of the interrelated areas of supply chain management, the term *green distribution* has also been used to describe the whole process of integrating environmental concerns into transportation, packaging, labelling and reverse logistics (Shi et al., 2012).

*Reverse logistics* is often used as a synonym to efforts to reduce the environmental impact of the supply chain by recycling, reusing and remanufacturing. However, originally green logistics was used to describe the movement of the material against the primary flow in the form of commercial returns, wrong deliveries and recalls etc., i.e. from the customer towards the producer. (Rogers & Tibben-Lembke, 2001.) In addition to reverse logistics, *closed-loop supply chain* has also been used to emphasize that the reverse flow of material (e.g. Zhu et al., 2008). However, the activities motivated mainly by environmental concerns might be better labelled as green reverse logistics (Hazen, Cegielski & Hanna, 2011) or in the more general terms of green or environmental logistics (Rogers & Tibben-Lembke, 2001) instead of reverse logistics or closed-loop supply chains.

The above-mentioned concepts are mainly used to describe the actions taken by the logistics service provider side. *Green supply chain management* (GSCM) is a more extensive concept that has been gaining increasing interest among practitioners and academia and is mainly directed towards manufacturing companies. The term implies that the focus of environmental management has shifted from a facility or organisation level to supply chain level (Linton et al., 2007). Srivastava (2007) defines that GSCM is ‘integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing



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processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life.’ GSCM is also known as *environmental supply chain management* (ESCM) (e.g. Zsidisin & Siferd, 2001; Walker et al., 2008). Some authors (e.g. Seuring & Müller, 2008; Craig & Carter, 2008) use *sustainable supply chain management* (SSCM) as a synonym of GSCM or ESCM although they mostly focus on the environmental aspect of sustainability, thereby paying less attention on economic and social aspects. According to Zhu et al. (2005) GSCM is strongly related to inter-organisational activities such as industrial ecosystems, industrial ecology, product life cycle analysis, extended producer responsibility and product stewardship.

GSCM is often described to consist of green purchasing, green manufacturing, green distribution/green marketing and reverse logistics (Hervani et al., 2005). *Green* or *environmental purchasing* or *green supply* refers to efforts to improve environmental performance of purchased inputs or of suppliers that provide them (Bowen et al., 2001). *Green manufacturing* is typically tried to be achieved by various types of environmental practices, such as pollution control, pollution prevention and product stewardship (Hart, 1995). The definitions of GSCM emphasize that environmentally conscious practices are evident in all stages of the supply chain and the product life-cycle (Hervani et al., 2005). Furthermore, Vachon and Klassen (2006) divide these *green supply chain management practices* into two sets: one of them being *environmental monitoring* and the other *environmental collaboration*. In the former the focus is on arm’s length transaction in which the buying organisation evaluates and monitors its suppliers, and in the latter the environmental solutions are developed jointly.

GSCM activities aim at achieving market advantages and profits while reducing environmental impacts. One generally used concept to measure the effect of supply chain activities on natural environment is the *environmental* or *ecological footprint*. It accounts for human demand on global biological resources and compares the level of consumption with the available amount of bioproductive land and sea area and has been designed to show whether this ‘sustainability threshold’ is exceeded (Wiedmann & Barrett, 2010). Lately the use of *carbon footprint* has increased rapidly but the question still remains whether it should contain only carbon dioxide emissions or other greenhouse gas emissions as well (Wiedmann & Minx, 2007).

The increasing interest in environmental issues has led to the development of voluntary environmental management systems. *Environmental management systems* (EMS) is ‘a collection of internal efforts at formally articulating environmental goals, making choices that integrate the



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environment into production decisions, identifying opportunities for pollution (waste) reduction and implementing plans to make continuous improvements in production methods and environmental performance' (Khanna & Anton, 2002). The most commonly used framework for an EMS is developed by the International Organization for Standardization (ISO) for the ISO 14001 standard. In addition, for example the European Parliament has created its own environmental management system, EMAS. (Gonzalez et al. 2008.) In order to obtain a certification an *environmental audit* conducted by a registered external auditor is required (Rondinelli & Vastag, 2000).

## 2.1 Where is the Footprint coming from?

Different types of actors can use different approaches to contribute to environmental sustainability. These approaches can be viewed from macro and micro perspective. Actions in the macro domain are taken by governments and other legislative authorities, while in the micro domain the actions are taken by the companies (Aronsson & Huge-Brodin, 2006). When viewed from a supply chain perspective, the micro domain can be further divided into the logistics service users (manufacturing, trading) and logistics service providers. The decisions concerning the actions to be taken can be made at different levels: strategic, tactic and operational. Each level indicates different scope and time span of the decision. In general, the policy makers' decisions are prepared for several months and even years beforehand, whereas logistics service providers and users also make plenty of day-to-day decisions. Figure X illustrates some of the actions taken by different actors that impact on the environmental footprint. It is not meant to be conclusive but to provide some examples on what kinds of activities affect the environmental footprint.

*Table 1: Actions Taken by Different Actors to Impact the Environmental Footprint*



**Logistics service users  
(manufacturing, trading etc.)**

**Logistics service providers**

**Legislative authorities**

Hours / Days	Weeks / Months	Years	Decades
Use of renewable resources Use of recycled materials Waste and by-product management	Supplier selection Auditing and monitoring of suppliers Production scheduling Inventory levels	Green strategy formulation Environmental management systems Choosing distribution channels New technologies Reducing demand for transport Eco design and packaging Energy efficiency agreements Recycling and remanufacturing programmes	
Eco driving Consolidation Postponement	Education Driver incentive schemes Route optimization Modal choice Alternative fuels	Green strategy formulation Environmental management systems Energy efficiency agreements Network design Less polluting fleets	
	Advice and exhortation	Taxes and financial incentives, e.g. energy taxes and subsidies Regulations, e.g. Sox Emission Control Areas Reducing demand for transport	Changes to infrastructure: road networks, railways etc. Liberalization and privatization of markets Reducing freight transport intensity



Management can take several approaches to greening the supply chains. Some firms choose to be reactive and commit minimal resources, while more proactive firms may choose to seek value by strategically committing to environmental sustainability and by integrating environmental policy in strategy. (van Hoek, 1999.) Formulating environmental strategy is equally important for both logistics service users and providers. An *environmental management system* (EMS) can be implemented to address environmental practices within the organisation. It is used to formally articulate environmental goals, to make choices that integrate the environment into production decisions, and to identify opportunities for pollution reduction and to implement plans to make continuous improvements (Khanna & Anton, 2002.) The two most widespread EMSs in Europe are ISO 14 001 and EMAS (Gonzalez, Sarkis & Adenso-Diaz, 2008).

Green purchasing or green supply attempts to improve environmental performance of purchased inputs or of suppliers that provide them (Bowen et al., 2001). Green purchasing enables to “green” specific issues, such as to reduction the waste produced, to substitute material through environmental sourcing of raw materials and to minimize the use of hazardous materials



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(Rao & Holt, 2005), e.g. through materials that are either recyclable or reusable, or have already been recycled. Supplier selection is an important decision at this stage. (Sarkis, 2003.) Supplier evaluation and development forms another important part of green purchasing (Zsidisin & Siferd, 2001). The survey study by Holt and Ghobadian (2009) revealed that over 50 % of UK manufacturers used informal supplier assessment and evaluation practices and over 30% used formal systems. Greener production is typically addressed through various types of environmental practices, such as pollution control, pollution prevention and product stewardship (Hart, 1995). It can be achieved by using renewable and recycled materials and by incorporating reverse logistics so that waste generated in the production processes are processed and recycled into the production phase (Rao & Holt, 2005).

There is a growing trend to outsource transport and logistics services to third party logistics service providers. Logistics service buyers increasingly ask for information on environmental performance of logistics service providers. (Wolf & Seuring, 2010.) Network design, planning and management are some of the pivotal issues to be considered by logistics service providers. Environmental sustainability usually calls for fewer shipments, less handling, shorter movements, more direct routes and better space utilization. Network design has an impact on fill rate, e.g. by increasing the size of warehouses, by centralizing distribution and by changing the location of warehouses. Consolidation is a central aspect to logistics systems on many levels, since consolidation of freight affects fleet size, vehicles, container and package sizes. (Aronsson & Huge-Brodin, 2006.) Other operational measures include e.g. educating and training drivers on eco-driving leads to reductions in fuel consumption (Helmreich, Bonilla, Akyelken, Düh & Weiss, 2009).

Although the supply chain to the retailers were optimized in terms of environmental sustainability, the importance of ‘last mile deliveries’ cannot be underestimated. Browne, Rizet, Leonardi and Allen (2008) note that personal shopping trips can use more energy than the whole supply chain before, even if production is included. Hence, the consumers should be made aware of the environmental effects of their shopping behavior. Growing online retail can reduce these effects and retailers can actively aim at reducing their share by e.g. consolidating orders and by adopting off-peak/out-of-hours deliveries, allowing delivery vans to run more of their mileage at fuel-efficient speeds. (Edwards, McKinnon & Cullinane, 2009.)

In the macro domain, the harmful effects of logistics have been recognized long ago. The transport strategy of the European Union highlights development needs towards sustainable



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transport and promotes multimodal and rail transport (European Commission white paper, 2011). Several policy instruments used by legislative bodies have long-term impacts on the supply chains. European commercial air transport and energy intensive manufacturing sectors are subject to the European Union Emissions Trading System (EU ETS). According to European Commission (2013a), the EU ETS is “a cornerstone of a cornerstone of the European Union's policy to combat climate change and its key tool for reducing industrial greenhouse gas emissions cost-effectively”. The system applies to emissions of carbon dioxide (CO<sub>2</sub>) from power plants, energy-intensive industry sectors and commercial airlines. The EU ETS works on the 'cap and trade' principle. A 'cap' refers to the limit of the total amount of certain greenhouse gases that can be emitted by the factories, power plants and other installations in the system. Within the cap, companies receive or buy emission allowances that can be traded with one another as needed. After each year a company must surrender enough allowances to cover all its emissions or it will be imposed heavy fines.

Apart from financial incentives, governments can use regulation to affect vehicle design and operation, the status of freight operators, the tariffs they charge and even the capacity of the freight sector. Furthermore, freight markets that are beneficial for environment, such as rail transport, can be liberalized and privatized. Infrastructure and land-use planning has a long-range impact in the spatial structure of the supply chains and modal choice. Governments also have a central role in promoting best environmental practice, often in close collaboration with trade associations. Climate change can ultimately lead to the need to limit the growth of ton-kilometers. Either the level of material consumption can be brought down or the structure of the supply chains can be changed. The latter can be achieved by e.g. promoting more localized sourcing and production and more centralized warehousing. (McKinnon, 2012).



### 3. ECONOMICS OF GREEN LOGISTICS

Understanding the key economic trade-offs of freight transportation is a prerequisite for designing efficient carbon emissions mitigation policies. After reviewing the main regulatory policies based on the pricing of carbon emissions, we argue that these regulatory policies have a limited potential for supply chain carbon emissions reduction due to the relative price inelasticity of freight transportation. A short example is also presented in order to illustrate the effect of a carbon tax on modal shift. Finally, some other types of regulatory policies that may indirectly have an effect on supply chain carbon emissions are reviewed.

#### 3.1 Pricing of carbon emissions

The pricing of emissions has been proposed as an important mechanism to curb their growth. In general, two types of pricing can be distinguished, namely taxation and cap-and-trade systems.

In a taxation system, emissions are taxed by a certain financial penalty. Taxation is typically applied to internalize external costs. For instance, societal costs such as pollution and noise are external to the industrial decision makers, and hence they are not part of a financial trade-off. Different types of taxes may be applied to account for carbon emissions. In the transportation sector, taxes on carbon emissions are usually charged indirectly by considering energy/fuel consumption, vehicle miles traveled, road usage or vehicle acquisition. Table 2 synthesizes the main types of taxes related to carbon emissions for transportation and provides examples of implementation.

Table 2: Taxes on Carbon Emissions

Types	Examples
Energy / Fuel consumption	Fuel tax
Vehicle miles traveled	Oregon mileage tax (pilot study)
Road usage	Eurovignette (EU)
Vehicle acquisition	Passenger car taxation (EU)

Fuel taxation is the most commonly used carbon emissions taxation mechanism. In Europe, taxes have gradually increased to reflect the increasing concern over the environment. In the



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United States, taxes on fuel have remained more or less the same. Due to the increase in oil price, actually the relative taxes have decreased in the US. Although the fuel price is still subject to market fluctuations, a fixed tax leads to price certainty on the taxes. Other advantages related to carbon taxation may be emphasized. First a regulatory policy based on carbon taxation is easy to implement and to enforce as it is simple and transparent. For the same reasons, this type of regulatory policy is effective in advance of any international treaty and is less vulnerable to abuse. Second, fuel taxation enables designing a carbon mitigation mechanism that is homogenous across all economy. On the other hand, there is no outcome certainty on imposing taxes. This could be viewed as a main drawback of such a regulatory policy. In theory, the tax rate should be equal to the marginal harm from the regulated parties. In reality, the setting of the tax rate is challenging because it is difficult to obtain accurate information about the costs and benefits of reducing emissions or mitigating climate change (Metcalf and Weisbach, 2009). Moreover, the pricing of carbon emissions implies that the marginal harm caused by carbon emissions can be expressed in monetary units. This idea is in accordance with the concept of weak sustainability that assumes significant possibilities for substitution between natural capital and human-made capital (Simpson et al., 2005). Weak sustainability is traditionally opposed to strong sustainability that states that some ecological services are critical to life support, i.e. that substitutability between the different sustainable development dimensions is not desirable (Gasparatos et al., 2008; Neumayer, 2004). Finally, carbon taxation may also encourage the phenomenon of carbon leakage, i.e. the shift of production to locations without regulation. In this case, the global level of carbon emissions may be increased due to extra transportation requirements and possibly extra emissions from production.

Unlike taxation, a cap-and-trade system provides outcome certainty. Under a cap-and-trade system, permits are required to emit, and the total number of available permits is limited (and freely tradeable). From the perspective of a firm, this also leads to a price associated with emissions (like in the taxation case), but the price is fluctuating in function of the market. Since the diesel price is however also uncertain, the impact on operational decision making is not that different between dealing with emissions costs under a cap-and-trade system and dealing with varying diesel (or kerosene, for that matter) prices. Examples of such cap-and trade regulatory policies are the emissions trading system (EU), the western climate initiative (US) and the regional greenhouse gas initiative (US). Note that emissions from transportation are generally out of the scope of such initiatives. An exception is the emissions trading system that includes



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aviation emissions since the beginning of 2012 even if the enforcement of such regulation has witnesses some difficulties. The enforcement of the emissions trading system has indeed been postponed for flights arriving at or departing from EU airports.

In addition to the guaranteed carbon emissions reduction provided by a cap-and-trade regulatory policy, this system is also recognized to achieve carbon emissions reduction at least cost by allowing market selection. Under this type of policy, the companies may indeed focus on the projects with the strongest carbon abatement potential.

A cap-and-trade system is however a relatively new legislation format that is more complex to monitor. Moreover, the detailed rules are complex. Finally, this complexity creates a risk of market manipulation. As an example of such manipulation, the emissions trading system has been subject to cyber-crime as well as value added tax fraud.

### **3.2 Price elasticity of Freight Transport**

The price elasticity of transport has been researched extensively in the transport economics literature. Most of the research focuses on passenger transport, and within this area the focus is mainly on automobile traffic elasticity as a response to fuel cost.

The work by Goodwin et al. (2004) concludes that subject to a 10% increase in the fuel price “volume of traffic will fall by roundly 1% within about a year, building up to a reduction of about 3% in the longer run (about 5 years or so)” indicating elasticities of 0.1 and 0.3 respectively. Looking at related factors, he concludes that the same price increase of fuel (10%) leads to “efficiency of the use of fuel [rising] by about 1.5% within a year, and around 4% in the longer run”, suggesting that there is a response by car manufacturers and subsequently by drivers in the change of the fleet, but less so in terms of vehicle miles travelled. An important effect mentioned by Goodwin is the income effect: if income rises by 10%, the “number of vehicles, and the total amount of fuel they consume, will both rise by nearly 4% within about a year, and by over 10% in the longer run. However, the volume of traffic does not grow in proportion: 2% within a year and about 5% in the longer run” (Goodwin et al., 2004).

In the context of international tourism flow, Tol (2007) develop a simulation model to study the impact of a carbon tax on aviation fuel. The study shows that a carbon tax of 1000\$/t CO<sub>2</sub> would decrease the carbon emissions from international aviation from 0.8%. This result illustrates the limited impact of a regulatory policy based on taxation in curbing carbon emissions from transportation.



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With regard to freight, data is more sparse. The work by Goodwin et al. (2004) shows that overall elasticities, both in terms of fuel bought and vehicle miles travelled are even smaller if the fleet considered is both commercial and private. This would suggest that commercial fleet elasticities are considerably smaller than those for passenger vehicles. As a potential explanation they argue that car owners are less rational in their decision making and would only look at the directly observable variable cost of operating a car (i.e., fuel) when making a decision on how much to drive, and not take issues such as depreciation and maintenance into account, while this would be less so for commercial vehicle operators. Graham and Glaister (2004) provide a more extensive review of studies that investigate freight transport price elasticities, suggesting substantially higher elasticities, in a few cases even exceeding unity. Most of the studies are however old (at least 20 years) at it is unclear to what extent findings would hold in current markets. It could be argued that the cost structure has changed over time, with especially labor cost increasing as a share of the cost price. The review by Graham and Glaister (2004) does suggest clearly that elasticities for road transport over long distances are substantially larger than over short distances, suggesting opportunities for modal shift over long-distance traffic as a consequence of price increases.

An interesting, and much more detailed study than the usual aggregate econometric modeling on which many of these results are based is the work by Beuthe et al. (2001). They develop a detailed simulation model of a multi-modal transport network, parameterize it using actual cost, and then optimize in the network from the perspective of the shipper. They deduce the elasticities from the decisions resulting from these optimizations. Their results suggest that total tonnage shipped is completely inelastic, while tonkilometers is more elastic, leading to modal shift over longer distances.

This relative price inelasticity of freight transportation implies that pricing emissions would only marginally affect the global level of carbon emissions from the transportation sector.

### **3.3 Other Emissions Mitigation Policies**

#### **3.3.1. Technical regulation**

Technical regulations that impose maximum requirements on fuel consumption and/or on emissions associated to transportation are generally only applicable to new vehicles entering the market. In Europe, a standard for trucks has been in existence for pollutants such as SO<sub>2</sub>, NO<sub>x</sub>,



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and particulate matter. These Euro-standards also have an indirect effect on the level of carbon emissions even if there are no direct requirements associated to carbon emissions.

The costs of conventional regulations are often invisible. Therefore, they are often criticized for costing more than needed to achieve a particular environmental target, since uniform targets are imposed on a group of heterogeneous emission sources. Consequently, investments are not necessarily channeled to creating the largest marginal environmental benefits (Dessler and Parson, 2009).

Dessler and Parson (2009), conclude that, over the past 30 years, conventional regulations have brought large environmental improvements. It should be noted that these have been largely related to pollutants with local environmental impact, such as ozone and particulate matter. In general technical standards have an impact on emissions over time. Response is generally slow due to the fact that they generally apply to new vehicles only. If technical standards for greenhouse gases were to be applied, the likely global effect is going to be even slower, as old trucks that come off the developed markets are exported to emerging and developing economies, and could be used for an additional number of decades in those countries.

### **3.3.2. Innovation support**

Fostering the emergence of low-carbon technologies may have a strong effect on carbon emissions reduction. Several tools are available to support companies in their innovation efforts. First, technical regulations such as standards may be viewed as emissions mitigation policies that foster innovation. Second, innovation may be supported by subsidizing, granting and funding. Such innovation support activities are often referred in the literature on emissions mitigation policies as induced technological change. Kempfert and Truong (2007) study the impact of emissions stabilization scenarios with and without induced technological change. They find that emissions reduction targets are generally achieved by declines in production if technological change is not induced. This decrease in production translates into an overall welfare reduction. On the other hand, they argue that emissions mitigation result in fewer GDP drawbacks in case of induced technological change. In a review paper on technological change in economic models and environmental policy, Löschel (2002) shows that the incorporation of induced technological change tends to reduce the costs of environmental policy, accelerates abatement and may lead to positive spillover and negative leakage.



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### **3.3.3. Infrastructure investment**

In the literature on emission mitigation policies, public expenditures are usually mentioned as an important category, referring to public buying (greening the purchasing of the government) and investments into R&D on sustainable energy. For transport, investments in public infrastructure should be part of this category, due to the fact that in transport energy efficiency and cost often go hand-in-hand. Rail and barge transport are not only causing lower greenhouse gas emissions than road transport, they are also cheaper. This implies that if the rail and inland water systems have sufficient capacity and are reliable, shippers would tend to move cargo off the road to water and rail. Public investments determine the availability of capacity on the various modes of transportation by investments in motorways, rail tracks, and canal locks. Recent examples show strong anecdotal evidence for this move, such as the modal shift in the Netherlands from road to rail after opening a new and dedicated cargo rail track, and the increase in the use of rail traffic in China after passenger traffic was moved from the conventional rail system to the high-speed rail system. We are not aware of large-scale studies documenting the consequences of infrastructure investment on emissions reduction, and the relative cost and effectiveness of these compared to other policies.

### **3.3.4. Disclosure requirements**

The policy makers may also enact regulations to enforce companies to disclose their performance in terms of carbon emissions. By doing so, the companies may be inclined to reduce their carbon emissions in order to be perceived as environmentally friendly by stakeholders. For instance, the companies may be required to publish a sustainability report. Carbon labeling also enters into this category. We are not aware of any paper studying the consequences of disclosure requirements on emissions reduction. The closest situation is studied by Kolk et al. (2008), where institutional investors urge firms to voluntarily disclose extensive information about their climate change activities. They prove that such initiative has been successful in increasing the number of disclosing firms, but that the effects on carbon emissions reduction are hardly evaluable.



## 4. COMPANIES’ FIVE SUSTAINABLE PRESSURES

The role of companies in implementing sustainable development actions is indisputably recognized. “It has become increasingly clear that business must play a central role in achieving the goals of sustainable development strategies” (Elkington, 1994). Indeed, companies may strongly leverage sustainability actions. For instance, companies may design and produce environmentally and socially responsible products. However, the companies need motivations to pursue sustainable development goals. In this section, a synthesis of some sustainable pressures is presented. We refer to sustainable pressures to encompass both opportunities and threats that the companies may take into account to act in a more sustainable way. We propose to classify the sustainable pressures into five categories. This classification is not purposed to be exhaustive. However, we have tried to give an overview of the main sustainable pressures on companies.

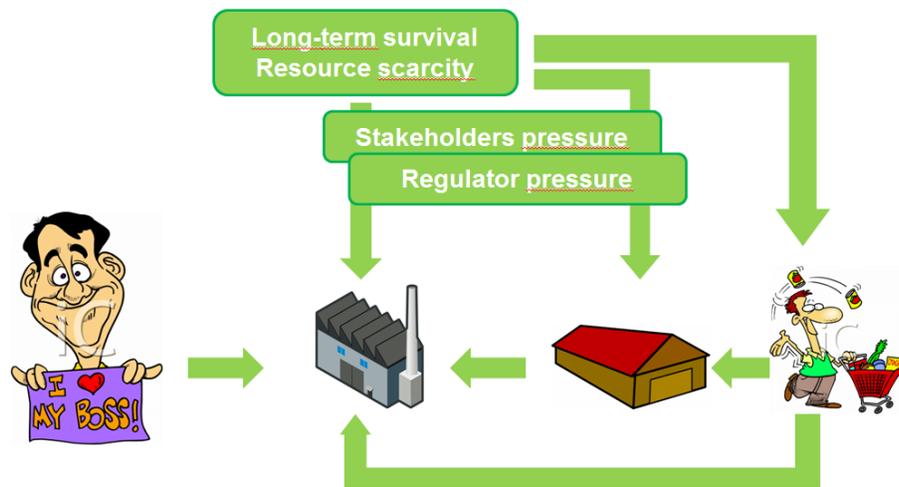


Figure 1: Pressures on Companies to Act.

Figure 1 synthesizes our classification. The five main sustainable pressures on companies are linked to resource scarcity, regulatory pressures, customer awareness, stakeholders’ pressure and employees’ motivation.

### 4.1. Resource scarcity

The first type of companies’ sustainable pressure is linked with non-renewable and renewable resource depletion. The concept of sustainable development was initially proposed as an answer



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to resource depletion issues. Resource depletion may indeed affect companies in several ways. A dependency on a scarce resource may affect companies due to speculation, price manipulation and political intentions. Resource depletion may also cause civil and transnational conflicts influencing both supply and demand. To tackle resource depletion problems, companies may diversify their supply sources, design products requiring low resource consumption or invest in cleaner technologies. Natural resource depletion problems thus require companies to implement sustainable development actions.

## **4.2. Regulations**

The second type of sustainable pressure is generated by governments and international bodies. The United Nations and national governments have indeed been the driving force behind sustainable development. Once the central role of companies in achieving the goals of sustainable development strategies has been recognized, governments and national bodies started setting up political tools requiring companies to operate in a sustainable manner. The risk of more stringent regulations in the future may also motivate companies. “To start with, corporations get involved with sustainability programs forced by legislation. Some companies anticipate such legislative changes, in order to gain some competitive advantage from acting as first movers” (de Brito et al., 2008).

## **4.3. Customer awareness**

The third reason for companies to focus more on sustainable development actions is the increasing customer awareness on sustainability issues (Blengini and Shields, 2010; Jaffry et al., 2004; Vlosky et al., 1999). Customer awareness is indeed a strong pressure for companies as it may positively affect the business for two reasons. First, selling sustainable products may be a way to attract more customers. Second, sustainable products may deserve a price premium. The DHL green trends survey on end consumers and business customers thoughts about green logistics illustrates these facts (DHL, 2010). The main findings of this survey may be summarized as follows:

- Climate change is viewed as the most prominent challenge faced by the world.
- Logistics is perceived as strategically important for carbon emissions reduction.
- Business customer are inclined to use green logistics.
- Business customers have huge expectations towards government.



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Moreover, half of the interviewed consumers expressed the view that they would favour a company with green solutions over a cheaper one in the next ten years. The customer willingness to pay for a price premium is however hardly predictable as a gap often exists between intention and action (Vermeir and Verbeke, 2006). For instance, Vanclay et al. (2011) recorded the sales of 37 products that were labeled to indicate embodied carbon emissions. They found that the change in consumption patterns was substantial only when the green-labeled products were also the cheapest. Upham et al. (2011) also assess the public perception of a UK carbon labeling trial. They found that there was little evidence of a willingness to use labels for product selection.

#### **4.4. Stakeholder pressure**

Enhancing the company image is often argued to be a company's motivation for establishing sustainability programs. Continuous improvements in information technologies indeed lead to the advent of the global information society. Whatever happens wherever in the world may thus affect the company's business. In this context, companies are under pressure to disclose more and more about their environmental goals and performance (Elkington, 1994). This public opinion, non-governmental organization and other stakeholders' pressure is very intense for companies. This phenomenon is amplified by government regulations requiring companies to communicate about their sustainability performances.

#### **4.5. Employees' motivation**

Finally, the fifth identified sustainable pressure is self-motivation. Companies may indeed have "the desire to do the right thing" as reported by Lieb and Lieb (2010) survey. In this sense, sustainability may be viewed as an entire part of company's values. This integration of sustainable development in the strategic vision of companies may also be beneficial for employees' motivation. Modern employees are more and more focused on a positive and responsible company culture. This may also be a valuable argument to attract skilled employees as more and more employees argue that they would choose working for a company with strong sustainability commitments.



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## **5. IMPACTS FOR DEVELOPING COUNTRIES**

The above outlines a variety of different measures that could be taken by policy makers. In all measures, the private sector response needs to be taken into account. Logistics activities are part of international supply chains, and the measures to be implemented need to take into account that the policies are aligned with the anticipated response of private operators. In that respects, pricing is not effective in many cases, and measures should further enhance and strengthen the developments in the private sector.

In the text below, we will summarize the main factors that impact the current status of developing countries in the greening of their logistics.

### ***1. Lack of footprinting standards***

“To measure is to know” as the saying goes, is highly relevant for most of the developing countries. Most of the current carbon footprinting models have been based on either North America or Europe, and little reliable data or models exist for developing countries. As a last resort, policy makers and companies usually take the reference models from the developed world to measure their emissions. Sparse studies that have been conducted, demonstrate that fuel usage is substantially worse in developing countries due to poor road conditions, an aged fleet, poor driving conditions and poor driver behavior. It is important that more reliable measurement standards for carbon footprinting in developing countries become available, such that shippers that are greening their supply chains may make better informed decisions.

### ***2. Poor regulation of the transport sector***

The transport sector is usually poorly regulated. This has effects on matters such as safety and labor conditions, and also on fuel consumption. Gradual fleet renewal is important to reduce emissions. Some countries have been successful by banning the import of old cars, but similar programs for trucks have barely been put in place. Simultaneously, it should be realized that the costs of transport are still high despite the low labor cost, the often subsidized fuel costs, and the old fleet, due to poor coordination of transport. Long journeys with unbalanced flows often lead to trucks waiting very long to obtain return loads, for instance.

### ***3. Little attention for any pollution***



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Governments in developing countries have relatively little attention for Green House Gases. If pollution by the transport sector receives attention, it is usually focused on local pollutants. Starting work on greening supply chains by reduction of local pollutants is a good starting point, as this creates local support, and in many cases the reduction of local pollutants go hand-in-hand with reductions of green house gases.

#### ***4. Few infrastructure alternatives***

Research within Europe has demonstrated that shippers are usually willing to switch to greener modes of transport as usually the cost are also lower. The main impediment is usually the availability of reliable alternatives. Proper analysis of transport infrastructures across the country, and the bundling of transport along corridors.

As discussed above, international shippers can play a major role with the greening of logistics. Projects should be conducted that involve those shippers in the policy changes that are considered. Especially voluntary (and often industry-driven) mechanisms have been successful, such as the EPA SmartWay program in the US, the Lean and Green Program in the Netherlands, and the Greenfreight Europe Program.

*References available upon request.*