Ways of Evaluating and Mitigating CO_2 Emissions in Goods Transport at Firm Level

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PREFACE

Transportation of goods has various impacts on the environment: energy consumption, land use, noise, water and soil pollution, local air quality, climate change and others. Emissions from mobile sources used for freight transport include carbon dioxide, nitrogen oxide, sulphur dioxide, non-methane hydrocarbons, particulate matter and hydrofluorocarbon 134a used in air conditioning.

The climatic impacts of emissions from freight transport are more than the direct impacts from carbon dioxide. In the case of air transport it includes the direct effects of water vapour, the indirect forcing on climate resulting from changes in the distributions and concentrations of ozone and methane as a consequence of aircraft nitrogen oxide (NO_X) emissions, the direct effects (and indirect effects on clouds) from emitted aerosols and aerosol precursors, and the climate effects associated with contrails and cirrus cloud formation.

To correctly capture the climate impacts of freight transport emissions and to develop mitigation strategies one has to consider more than just the emission of CO_2.

The contribution of freight transportation to worldwide CO_2 emissions depends on two major factors - the rate of growth in freight movement and changes in the emissions characteristics of mobile sources. In 2006, world merchandise trade recorded a growth of 8 per cent. This is double the growth rate of world GDP, and highlights the effect of specialisation and globalization. According to a recent study by the European Environment Agency[1], global emissions of CO_2 increased by 27% during the period 1990 -2004, from 20,463 to 26,079 million tonnes CO_2. Energy demand from the passenger and freight transport sectors increased by 37% over the same period.[2]

The effect of the growing distance between production and consumption and of international trade is illustrated by the big increase in the world container port throughput in 2006 by 13.4%.

While fuel efficiency of engines has steadily improved over the years the growth of international trade and other trends such as specialisation, lower inventories, just in time deliveries, etc. have largely counteracted this trend. It has even resulted in more energy intensive transport as is the case in international shipping as a result of larger and faster ships which require greater power. Over the past 20 to 30 years fleet installed power has grown at rates faster than global trade growth.[3]

This situation is clearly unsustainable and public policy makers as well as shippers, receivers of goods and transport companies must develop and implement policies to improve the environmental performance of freight transport activities and of supply chains.

This report focuses on the drivers for corporate environmental responsibility related to freight transport, the various strategies for mitigating CO_2 and other greenhouse gas emissions, the calculation of emissions from mobile sources at firm level and recent initiatives in all these fields.

1. BUSINESSES AND ENVIRONMENT

1.1 Drivers for a corporate environmental responsibility

Reducing the consumption of energy and raw materials and limit emissions and waste from production and logistics processes are key contributions that businesses can make to tackling local and global environmental challenges. But companies are not alike. They differ in the way they perceive climate change and their ability to have a positive effect on the environment. They differ in the way compulsory or voluntary measures to mitigate emissions will have an impact on their financial performance.

Corporate environmental responsibility (CSR) encompasses the voluntary actions and measures taken by companies to contribute to a better environment and to mitigate greenhouse gas emissions and other pollutants. The drivers of CSR are a mix of economical, social and political incentives and risks.[4] Economic drivers are company image, pressure from customers, pressure from business partners, damages, costs and competitive advantages. Social drivers are pressure from Non Governmental Organisations, local communities, the media, religions, and science. Political drivers are legislation, licences to operate, political support and pressure.

With regard to goods transport or more generally to supply chains, it is clear that corporate environmental responsibility is not limited to the individual company but includes other companies downstream and upstream of the supply chain. Companies have first tier supplier(s) and first tier customer(s), but total supply chains from raw material production to end consumption and disposal include many actors.

1.1 Different pressure and impacts

Large consumer products manufacturers and retailers are under much more pressure from end consumers and their councils than transport companies and raw material suppliers.

Large public corporations are more visible and need to be more transparent than small family-owned companies.

An increase in one of the cost elements of transport activities will have a much larger impact on the bottom line of transport providers than on the cost of companies that employ transportation providers.

Shippers, transport companies, logistics service providers, receivers of goods, wholesalers and retailers are part of complex logistics networks but their respective power position is not the same. Retailers are more able to push the burden of additional cost upstream or downstream in the supply chain.

The perception of additional associated costs in time and money but also of the benefits of emission mitigation projects will be different between companies.

Governments promoting corporate environmental responsibility and companies initiating total supply chain CO_2 mitigation projects need to be aware of these differences. Differentiation per sector and actor is an important success factor for the adoption by companies of corporate environmental responsibility and for their willingness and ability to mitigate CO_2 emission of their freight transport.

2. WAYS OF MITIGATING CO_2 EMISSIONS

The contribution of freight transportation to worldwide CO_2 emissions depends on two major factors - the rate of growth in freight movement and changes in the emissions characteristics of mobile sources. Companies can influence both aspects in different ways. The growth in freight movement can be reduced by (i) strategic changes in sourcing, (ii) logistics network design, (iii) operational improvements, and (iv) transport avoidance measures. Changes in the emissions characteristics of mobile sources are more related to technological improvements.

Companies depend on and interact with their external environment. External pressure to incorporate environmental aspects in business decision making and to develop mitigation strategies will come from rising energy costs, regulations, taxes, customers' requirements, etc. Pressures for change may also arise from a number of sources within the organization and the role of the CEO in the adoption of mitigation strategies and related cultural change within companies cannot be underestimated. Mitigation can be seen as an adaptation strategy; for most companies not yet as an adaptation to climate change impacts itself, but to a changing economic, political and cultural environment.

Environmental objectives can be achieved in synergy with other strategic and financial goals. Measures to mitigate CO_2 emissions from transport activities often reduce logistics costs as they also focus on reducing energy consumption. The implementation of mitigation strategies often results in leveraged benefits as it stimulates critical business analyses because of the requirement to document business processes and evaluate alternative solutions.

2.1 Integrating environmental values into decision-making processes

It is generally widely accepted that the concept of integrating the environment into policy making is a key principle of moving towards sustainable development.

Environmental integration into government decision-making processes is well developed in several countries. The National Environmental Policy Act (NEPA) in the USA requires federal agencies to integrate environmental values into their decision-making processes by considering the environmental impact of their proposed actions and reasonable alternatives to those actions. Under NEPA Legislation all Federal actions that are likely to have significant effects on the quality of the human environment are required to include a detailed statement assessing the environmental impacts of such legislation or action.

Although there are a few examples of similar mandatory Environmental Impact Assessment related to the movement of goods at firm level, more examples can be found of companies that have voluntary integrated the environment in supply chain decisions at strategic and operational levels.

Some forerunners started with an Environmental Impact Assessment (EIA) to identify and assess the likely significant effects on the environment of logistics activities, the results of which are then taken into account in the decision-making process. Environmental Impact Assessment at strategic and operational levels can be used in combination with objectives and an emission baseline inventory to develop a well-informed emission reduction strategy.

Several factors need to be present for EIA to be successful:

- Senior executive support, involvement and leadership
- A well-defined strategic vision, company values and plan
- Clearly defined objectives
- High quality and rigorous application of assessment methodologies
- A baseline from which performance can be measured over time
- Development of environmental performance indicators
- Adoption of a cross-section approach
- Linking different planning levels
- Awareness raising
- Guidance and training
- Procedures for monitoring and auditing
- Procedures for internal communication and reporting
- External communication and statements

With regard to the movement of goods it has to include:

- A good knowledge of supply chain processes
- A good knowledge of alternative solutions
- Focus on total supply chains effects, not only on local optimization
- Involvement of suppliers and customers
- Procedures and guidance for measuring emission from transport sources
- Available data to calculate emissions from logistics sources
- Allocations keys to allocate emissions from sources to products flows

The impetus for the development of supply chain management was the awareness that local optimisations often resulted in a suboptimal total supply chain performance. The same is true for environmental performance improvements in supply chains. Collaboration with other partners in the supply chains is therefore an important success factor in mitigating greenhouse gas emissions of freight transport.

It is obvious that some sort of learning process will be required and that it is easier and advisable to start with internal supply chain practices where a company has the greatest control, before starting to work with supply chains partners to improve their - and the total supply chain - environmental performance.

The different areas in which the environmental performance of freight transport can be improved are described below.

2.2 International Sourcing

International trade is an important driver of economic development and value creation in both well-developed and developing countries. Trade leads to efficiency gains allowing countries and companies to specialize in what they are good at producing. The relationship between trade, development and the environment is complex and the subject of academic and political debate.

It is not always true that local sourcing has a better environmental footprint than long-distance sourcing.

An evaluation of the respective greenhouse gas emissions of different sourcing options has to be based on a total life cycle GHG emissions calculation including the emissions released as part of the processes of creating, modifying, transporting, storing, using, disposing and/or recycling.

Notwithstanding the public attention in some countries for issues such as food miles, carbon footprints, etc., only a very few number of companies have incorporated environmental impact assessments in their decision-making processes related to strategic sourcing decisions.

Higher and rising energy costs, transport capacity limitations and new trade regulations such as the imposition of carbon taxes and emission cap-and-trade systems will have a growing impact on sourcing decisions in the near future. In the longer run the damages of climate change itself will force companies to develop adaptation strategies related to strategic sourcing and their supply chains.

2.3 Logistics Network Design

Logistics Network Design is a complex process that requires decisions to be made regarding: (i) the selection of suppliers; (ii) the location of plants and warehouses; (iii) the assignment of raw materials to suppliers and of finished products to plants and warehouses; (iv) the flows of raw materials and finished products through the network, and (v) the choice of transport mode. These decisions must be made so as to satisfy customer demand while minimizing fixed and variable costs associated with procurement, production, warehousing and transportation.

The choice of logistics network has an impact on the energy consumption of the network and of freight transport in particular. To take environmental considerations into account for network design and to be able to take environmental effective decisions, new developments will be needed in supply chain planning applications. These modelling tools require a lot of data input and complex relationships.

An area where significant savings in energy and emissions can be made are collaborative logistics networks were companies have integrated or/and consolidated their supply chain. This kind of collaboration can be strategic, operational or at a coordination level. Even competitors can cooperate with each other in non-core areas such as freight transport. There are several examples of collaborative logistics networks where cooperation and competition are applied simultaneously. The advantages of collaborative networks are a much better utilisation of logistics assets and better coordination of logistics processes. It has resulted in lower emissions per product unit and the realisation of competitive advantages for the parties involved.

2.4 Transport avoidance

The need for transportation can be avoided in all phases of a product life. Reducing the demand for transport will result in lower emission and in lower costs.

Traffic avoidance can be defined as any innovative action integrating transport into production logistics to avoid freight transport. This means reduction of freight transport through modifications in production and distribution.

Examples of transport avoidance are:

- Reduction of volume and/or weight in the design phase of a product
- Reduction of the volume and/or weight of packaging
- The relocation of production and assembly processes closer to the place of consumption
- Reduction of distances by better visibility as regards availability of the nearest stock (e.g. network management of empty crates, pallets, containers, etc)
- Virtual auctions avoiding the movement of people and products to and from a physical meeting place
- The concentration of products by extracting some components (e.g. fruit juices)
- Electronic data exchange instead of the movement of physical information carriers (e.g. internet newspapers)
- Avoidance of emergency shipments
- Reduction of waste and return flows
- …

Connekt, a Dutch public-private initiative made up of 80 Dutch government bodies, companies and knowledge institutes has been promoting Transport Avoidance Strategies in the Netherlands. Connekt has developed a methodology and software tool, Digiscan, to help companies to identify opportunities as well as to calculate savings in transport as a result of transport avoidance and other transport efficiency alternatives.

2.5 Operational improvements

Improving the productivity of operational processes leads mainly to greater energy efficiency and therefore to carbon savings as well. Logistics and freight transport operational improvements have been used by companies for a long time to improve their financial performance. Until recently these improvements were evaluated in terms of cost reduction and service reliability and not in terms of environmental impact.

Integrating environmental impact assessment into operational decision making and improvement projects is needed to understand better the relationship between cost, service and environment. Since this is often a win-win scenario, it will create an opportunity for companies to speed up the improvement of the total performance of their freight transport operations.

Areas of improvement are listed below. Depending on their span of control these solutions can be implemented by transport companies, shippers or receivers of goods, authorities or by collaborative networks of partners in supply chains.

2.5.1 Supply chain

- Supply chain integration
- Supply chain consolidation
- Collaborative logistics networks
- Intermodal transport and modal shift
- Corridor specific coordination
- …

2.5.2 Trucking

- Collaborative transport networks
- Transport pooling
- Better transport planning
- Eco Driving Training
- Reduced empty mileage
- Reduced highway speeds
- Reduced overnight idling
- Reduced pickup/drop off idling, …

2.5.3 Rail

- Reduced line haul speeds
- Reduced empty mileage
- Reduced switchyard idling
- Better traffic management systems
- Cross-border coordination
- Enhanced interoperability
- Double stack
- Longer trains
- …

2.5.4 Ports and shipping

- Cold ironing (Shore-to-ship electric power)
- Minimizing the use of diesel powered auxiliary engines while in port
- Reduced vessel speeds
- Use of larger ships
- Alternative fuels (LNG, ultra low sulphur diesel, electricity, ...)
- Hull and propeller cleaning in dry docks
- …

2.5.5 Air transport

- Use of continuous descent approach
- Improved air traffic control
- Increased load factors
- Optimal Flight Routes
- Reduced vertical separation minimums
- Reduced use of auxiliary power units
- Reduced use of reverse thrust
- Taxiing with fewer engines running
- Clean aircraft
- Polishing aircraft
- Electrification of ground support equipment
- …

2.6 Technological Solutions

Transport will remain largely oil based in the coming decennia. It will take time before innovative technologies such as hydrogen or electric powered vehicles will become available at an acceptable cost. The effect of these energy carriers on global climate change will depend on the degree that renewable primary energy sources will become available and on the degree that energy losses in the total energy conversion chain can be reduced.

Cost effective emission savings from transport are possible today by the implementation of following technological solutions:

Retrofit: After-treatment devices to remove emissions from the engine exhaust; e.g. Diesel Particulate filters, NOx catalysts.

Repower: Replacing existing engine with a new engine that meets lower emission standards.

Refuel: Alternative and cleaner fuels such as LPG, LNG, second generation biodiesel, etc.

Repair/Rebuild: More and better maintenance to ensure that engines operate at maximum energy performance.

Replace: Replacement by newer equipment that meets lower emission standards.

3. CALCULATION OF CO_2 EMISSIONS

Quantifying emissions will enable transport providers to access the emissions from their transport assets. It will give shippers as well as receivers of goods, such as retailers, the opportunity to calculate their supply chain emissions footprint. Quantifying emissions from mobile sources and supply chains provides the baseline from which emission mitigation strategies can be developed and performance can be measured over time. It will allow companies to set goals, to understand the tradeoffs between choices and to optimize their modes of freight transport.

3.1 The lack of standardisation

More and more carbon footprint calculators are available on the internet. The outcome of these calculators differs widely as various methodologies and emissions conversion factors are used. This is also the case for internet tools for measuring a business's carbon emissions. Discrepancies can even be found between the results of specific research. An example of this was the difference in results between two parallel projects to calculate the emissions for sea-going vessels in the Belgian part of the North Sea including ship movements and hotelling time in the major ports. One study came to a total of 1849 kton/year CO_2 versus 720 kton/year in the other study.[5] The lack of standardisation also creates a problem for application vendors intending to incorporate environmental data and analytics capabilities in supply chain modelling and planning software.

The advantage of a standard procedure and methodology to quantify emissions from freight transport activities at the corporate level are obvious. It facilitates:

- Companies to launch logistics environmental initiatives
- The exchange of environmental data within supply chains
- Collaborative projects
- The measurement of progress
- Verification and third party audits
- Benchmarking opportunities
- Suppliers to meet environmental requirements
- The use of reported emissions for academic research
- The integration of standard environmental data into future transport and supply chain modelling and management applications
- The establishment of voluntary emission registries
- The introduction of certification and labels

3.2 Existing procedures, data and guidelines

Although an international accepted standard is not available to calculate emissions from mobile sources and from the movement of goods in supply chains, there are procedures and guidelines available that can be used at a firm level. Some of them are international but very basic, others are more detailed but national. The guidelines from the Intergovernmental Panel on Climate Change are detailed and international but related to emission inventories at country levels.

Calculating the emissions footprint from goods movement requires more information than specific data per emission source. The emissions of a specific mobile emission source has to be allocated to a specific freight (in volume or weight) transported from point A to B. Extra information is needed to calculate the emission per mass or volume/distance such as the capacity and capacity utilisation of mobile emission sources. Most existing procedures and data are only relevant for the estimation of emissions from different mobile sources and not yet for the allocation to specific goods movements.

3.2.1 IPCC

The Intergovernmental Panel on Climate Change (IPCC) is a scientific intergovernmental body set up by the World Meteorological Organization (WMO) and by the United Nations Environment Programme (UNEP). The IPCC was established to provide the decision-makers and others interested in climate change with an objective source of information about climate change. The Task Force on National Greenhouse Gas Inventories (TFI) was established by the IPCC to oversee the IPCC National Greenhouse Gas Inventories Programme (IPCC-NGGIP).

The objectives of the IPCC-NGGIP are:

- To develop and refine an internationally-agreed methodology and software for the calculation and reporting of national GHG emissions and removals; and
- To encourage the widespread use of this methodology by countries participating in the IPCC and by signatories of the United Nations Framework Convention on Climate Change (UNFCCC).

The IPCC has established und maintain an Emission Factor Database, where users can find emissions factors and other parameters with background documentation or technical references to be used for estimating greenhouse gas emissions.

The IPCC methodology for the calculation of Greenhouse gases of mobile sources is a top- down approach using the aggregated data based on the sale of fuels while the methodology for measuring emissions of logistics activities at firm levels will be a bottom-up approach.

3.2.2 ISO 14064

The International Organization for Standardisation developed principles and requirements for organizations or company level GHG inventories.

The ISO 14064 consists of the following parts:

- Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals
- Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of green house gas emission reductions of removal enhancements
- Part 3: Specifications with guidance for the validation and verification of greenhouse gas assertions

These international standards create a good basic framework for quantifying GHG emissions at company level but are limited in guidance for specific areas such as transport activities.

3.2.3 Carbon Trust and Defra

The Carbon Trust and the Department for Environment, Food and Rural Affairs (Defra) in the UK co-sponsor the development of a Publicly Available Specification, PAS 2050, by the British Standards Institution for assessing the life cycle greenhouse gas emissions of goods and services. PAS 2050 will take into account the emissions that are released during transport, storage and handling of goods as part of the total life cycle emissions of goods.

3.2.4 Greenhouse gas Protocols

The Greenhouse Gas Protocol Initiative (GHG Protocol) was jointly convened in 1998 by the World Business Council for Sustainable Development (WBCSD) and the World Resources Institute (WRI). The GHG Protocols are standards for business and other organizations to inventory and report all of the GHG emissions they produce and for calculating reductions in GHG emissions from specific GHG-reduction projects.

Specific guidance has been developed to facilitate corporate-level measurement and reporting of greenhouse gases emissions from transportation and other mobile sources. The section addresses direct GHG emissions from owned or controlled mobile sources and indirect emissions from the use of transportation sources that are owned or controlled by other entities.

These greenhouse gas protocols and guidance are a good starting point and can be combined with ISO 14064 procedures.

3.2.5 California Climate Action Registry

The General Reporting Protocol provides guidance for businesses, government agencies, and non-profit organizations to participate in the California Climate Action Registry, a voluntary greenhouse gas (GHG) registry. The Protocol is based on the Greenhouse Gas Protocol developed by the WBCSD/WRI. The calculations and emission factors were selected based on technical advice provided by the California Energy Commission. One chapter provides guidance on calculating direct emissions from mobile combustion.

3.2.6 NTM

The Network for Transport and Environment, NTM, is a Swedish non-profit organisation, set up in 1993 with the aim of establishing a common set of values for calculating the environmental performance for various modes of transport. The members are Swedish companies including Volvo, Ikea, SKF and Arla Foods but also Swedish subsidiaries of foreign companies such as DHL and Kuehne & Nagel. A working group within NTM develops environmental performance data for goods transport.

The NTM methodology to measure emissions uses three different levels of detail:

- Average emission factors of vehicles/vessels
- Specified vehicle/vessel type
- Emissions calculations based on vehicle identity and consignment

Several aspects are taken into account:

- The number of tonnes of freight multiplied by distance (tonne-km).
- Type of vehicle / vessel
- Fuel type and quality
- Load Factor

NTM is most probably the first organisation to develop a methodology for the measurement of transport emissions at firm level. As it is a national member organisation the use of their methodology is limited in other countries.

3.3 New initiatives

3.3.1 US EPA

The US Environmental Protection Agency's Office of Transportation and Air Quality (OTAQ) is charged with protecting public health by addressing air quality and other environmental concerns related to transportation. The EPA has been initiating government-industry, voluntary initiatives that address environmental concerns associated with transportation. Current government–industry programs are the SmartWay Transport Partnership, The National Clean Diesel Campaign, and Clean Ports USA.

Another project is the development of protocols and tools which will help companies to calculate their CO_2 and criteria pollutant emission footprint from goods movement across all transportation modes. EPA envisions a model that can be incorporated into existing commercial logistics software.

3.3.2 Connekt

Connekt, a public-private initiative made up of 80 Dutch government bodies, companies and knowledge institutes finances two current projects to develop (i) procedures and guidelines for measuring emissions from logistics sources and (ii) a modelling tool to calculate emissions in supply chains.

3.3.3 Green Logistics Consultants Group

The Green Logistics Consultants Group is a worldwide international collaborative network of researchers and consultants with a proven general or specific expertise in areas where companies and regional or national governments can improve the socio-environmental performance of their supply chains or transport infrastructure.

One project of the Green Logistics Consultants Group is to foster cooperation and co-ordination between the organisations and initiatives described in this chapter and with others with the objective to (i) agree a worldwide accepted framework for the calculation of emissions of goods transport and supply chains and (ii) to create an international database with international and national information on emissions factors and logistics data.

3.3 The importance of transparency

Differences in outcomes in the calculation of emissions are inevitable as a result of differences in methodologies, logistics categories and data availability. Even if a common methodology is used there will be a potential variation in outcomes due to the need to define specific boundaries and allocation keys. The problem with this is that companies are able to influence the outcome of their carbon footprint calculation to a large extent.

A lack in transparency will lead to limited confidence in initiatives and communicated project assertions by companies. Within transport and logistics operations where several companies are involved, transparency is particularly needed to look further up and down in the supply chain and to understand the challenges and opportunities better.

Organisation such as the Global Reporting Initiative (GRI), and the Carbon Disclosure Project (CDP) promote transparency as a catalyst to improve environmental, social and economic improvement. The GRI is a multi-stakeholder governed institution collaborating to provide the global standards in sustainability reporting. The Carbon Disclosure Project is a non-profit organisation aiming to create a lasting relationship between shareholders and corporations regarding the implications for shareholder value and commercial operations presented by climate change. The Carbon Disclosure Project promotes the use of ISO 14064 and the GHG protocols for the calculation of GHG emissions in supply chains.

4. CONCLUSIONS

Companies can do much more to improve the environmental performance of their goods transport and supply chains. Companies can realise environmental objectives in synergy with other strategic and financial goals. A more environmentally friendly movement of goods often reduces logistics costs as it focuses on reducing energy consumption and on improving the total supply chain.

But it is also true that some economic trends, such as a shift to more offshore manufacturing and more frequent JIT deliveries, have a negative impact on the ecological performance of supply chains.

Whatever the effect on costs, it is obvious that environmental performance indicators, the adoption of a green logistics policy and effective green logistics measures will become important aspects of freight management and total supply chain management in the near future. Shippers and retailers as well as transport companies, logistics service providers, airport and port operators will have to integrate environmental values into their decision-making processes. A well-informed emission reduction strategy will have to be developed by companies to meet future requirements.

International institutions, governments, NGOs and associations can help companies to accelerate the introduction of corporate environmental responsibility and of strategies to mitigate the emissions of greenhouse gases and other pollutants from goods transport and other logistics activities.

There are companies that will only take environmental responsibility on board if they have to.
The drivers for corporate environmental responsibility are not only legislation and voluntary activity is no substitute for regulation. It is therefore important for policy makers to integrate voluntary approaches and government regulation into one policy, rather than considering voluntary initiatives as an alternative to legal instruments.

It is also important to bear in mind that companies are not alike. Governments and institutions have to take these differences into account when developing and promoting voluntary programs.

Integrating environmental issues into the core business requires extra data, analyses and process adaptations. This will be an additional burden for companies. Governments and international institutions can stimulate the acceptance of corporate environmental responsibility and can support the development of models, tools and common best practices.

Best practices related to the cost and service aspects of freight transport and supply chain management are well documented. The link between operational improvements and environmental improvements are obvious in a lot of cases, but supply chains are complex. Optimisation at one level does not mean that an optimum in the total supply chain is obtained. Environmental concerns are not only related to CO_2 and other greenhouse gas emissions. Other pollutants such as NO_X , SO_2 and particular matter must be taken into account to make the correct decisions related to modal shift and other supply chain issues. The development of a common framework for the measurement of emissions from logistics activities will be needed to calculate and compare different options. The same is true for the availability of detailed information on emission factors and logistics factors which are already to some extent available at national levels. Progress in this field will be needed to motivate companies to initiate and maintain well-informed policies that will result in lower emissions from goods transport.

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