ENGineering and INdustry Innovative Training for Engineers (ENGINITE)

PROJECT NUMBER
2017-1-CY01-KA202-026728

B1 course

Logistics and Supply Chain Management

Prepared by TUC

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Table of Contents

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Part A – General information

Title:	B4- Logistics and Supply Chain Management
Keywords:	Logistics, supply chain management, carbon footprint, global warming, CO_2 emissions, sustainable supply chain
Author(s):	Developed by Nikos Xekoukoulotakis
Duration:	1 day online reading/study on Google Classroom and 1 week face to face (f2f)
Language of materials	English and Greek
Type & number of sessions:	Online schedule: ● Online day 1: online reading/study on Google Classroom. Relevant material will be provided for the preparation of the f2f sessions. Face to Face schedule: ● f2f day 1 (3-hours session): presentation of the problem scenario, grouping, identification of learning issues within the groups, class-wide discussion of learning issues. ● f2f day 2 (3-hours session): group work, interviewing process, progressing on learning issues and solutions. ● f2f day 3 (3-hours session): group work, interviewing process, present new constrains and information relevant to the problem. ● f2f day 4 (3-hours session): group work, interviewing process for completing the deliverables, providing final guidance for the presentation. ● f2f day 5 (3-hours session): submission of the technical report & presentation (per group) of the progress and main outcomes for the given problem scenario. Self-evaluation and cross challenging for selecting the best approach.
Number of participating engineers:	20-25 engineers.
Groups' setting	Mixed gender, multidisciplinary groups of engineers, 5-7 members in each group (as per guidelines of PBL literature) Each team group will select its own leader.

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Part B – Module Overview & Key Learning Outcomes

B.1. Overview

This course aims to provide practical knowledge and technical skills for understanding, analyzing and managing logistics and supply chain of the industrial sector. Engineers will learn the basic principles of logistics, i.e., the process of planning, implementing, and controlling procedures for the efficient and effective transportation and storage of goods including services, and related information from the point of origin to the point of consumption to conform to customer requirements. Moreover, engineers will become familiar with the context of supply chain management, which is the management, across and within a network of upstream and downstream organizations, of both relationships and flows of material, information and resources, and they will realize that the purposes of supply chain management are to create value, enhance efficiency, and satisfy customers. Particular emphasis will be given to the global nature of the subject matter.

B.2. Key learning outcomes:

Upon completion of the course, participants should be able to:

- Describe the key concepts of logistics and supply chain management and their application in manufacturing and services context
- Understand the role of globalization and international trade in logistics and supply chain management
- Define the various logistics and supply chain strategies that companies employ in order to survive and compete within the complex and dynamic global environment
- Understand the fundamental operations of logistics and supply chains, such as transportation, procurement, inventory management, as well as warehousing and materials handling
- Discuss the ever-increasing role of technology in the supply chain
- Explain the role of information and finance flows in the supply chain
- Review the important roles of supply chain risk, robustness and resilience
- Understand what sustainability involves in the context of logistics and supply chain management
- Explain the basics of reverse logistics and the reasons for employing reverse logistics
- Review the many strategies and practices employed in logistics and supply chain management today

B.3. Course Material / Software

- All participants need to use their own PCs/laptops/tablets.

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Part C – Learning Scenario

C.1. Problem-based learning scenario

Within the framework of corporate social responsibility, the industry/company that you work intends to implement various environmentally friendly practices to contribute actively to the protection of the environment.
In this framework, the CEO of your company asks you to describe actions and strategies to reduce the carbon footprint of the supply chain. Provide a technical report to achieve the goal of 25/50, i.e., to reduce the CO_2 emissions of your supply chain by 25% until 2050. You have to prepare a comprehensive presentation and a technical report to provide to the CEO all relevant information. The technical report should contain a roadmap and an implementation plan.

Tips for the facilitator/instructor:

1. The following questions/topics will guide the engineers:

What is logistics and supply chain? Definitions and Examples.
What are the basic operations of the supply chain?
What is Corporate Social Responsibility?
What is climate change?
What are the impacts of climate change on humanity?
How climate change can affect businesses.
What are the risks faced by companies as a result of climate change?
Why it is important for businesses to reduce the environmental footprint of their supply chain?
What strategies companies can use to reduce their environmental footprint?
Policies to reduce CO2 emissions in the atmosphere.
What is the role of technology?
Measuring first: how to reduce something that you do not know how much it is?

The facilitator/instructor will guide the engineers to follow these steps:
Step 1: Choose a particular product or a service.
Step 2: Analyze its supply chain. Pay special attention to the various operations of the supply chain of that particular product or service.
Step 3: Which parts of the supply chain contribute more to the CO_2 emissions?
Step 4: Calculate (if possible) the CO_2 emissions associated with the supply chain of that particular product or service.
Step 5: Suggest possible ways of reducing the carbon footprint of the supply chain.

The technical report should take into account the following issues associated with the reduction of the carbon footprint of the supply chain:

- advantages
- disadvantages
- costs
- risks

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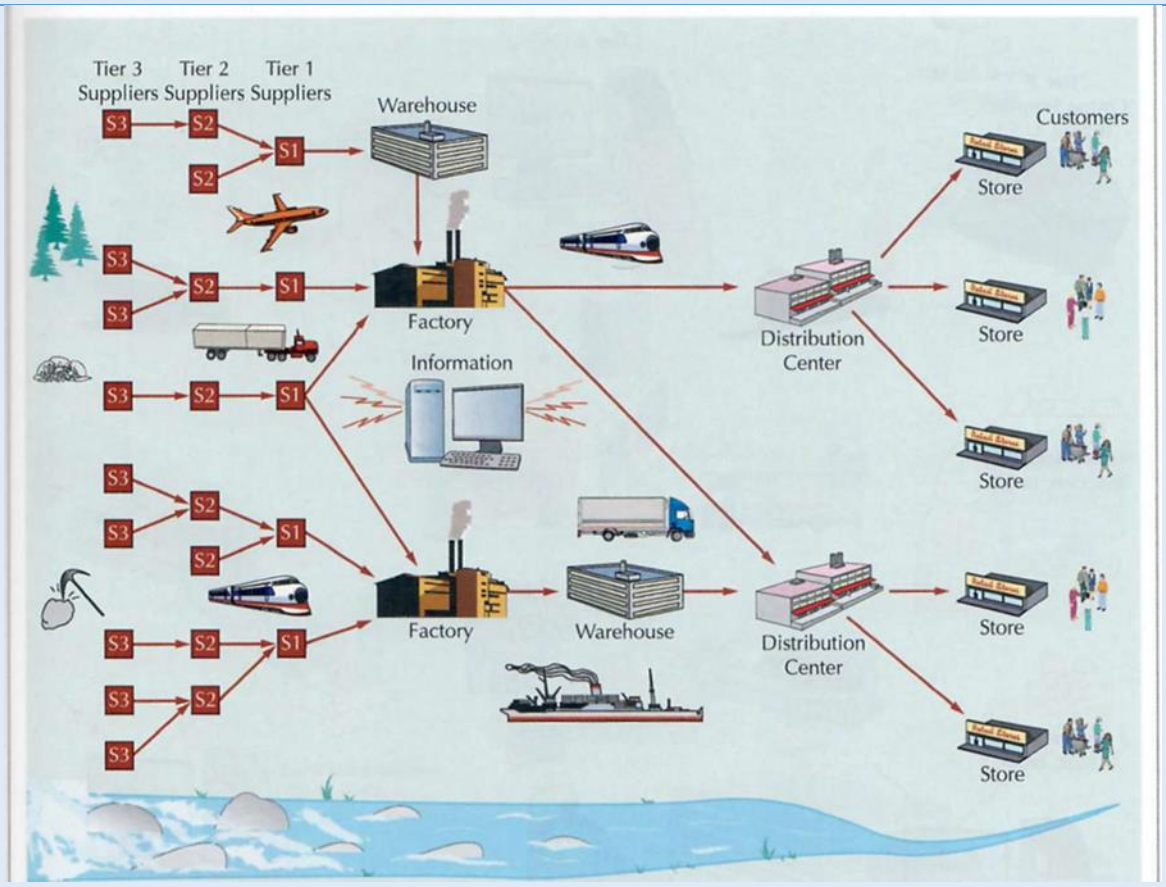
Relevant Images

Supply Chain



Supply Chain

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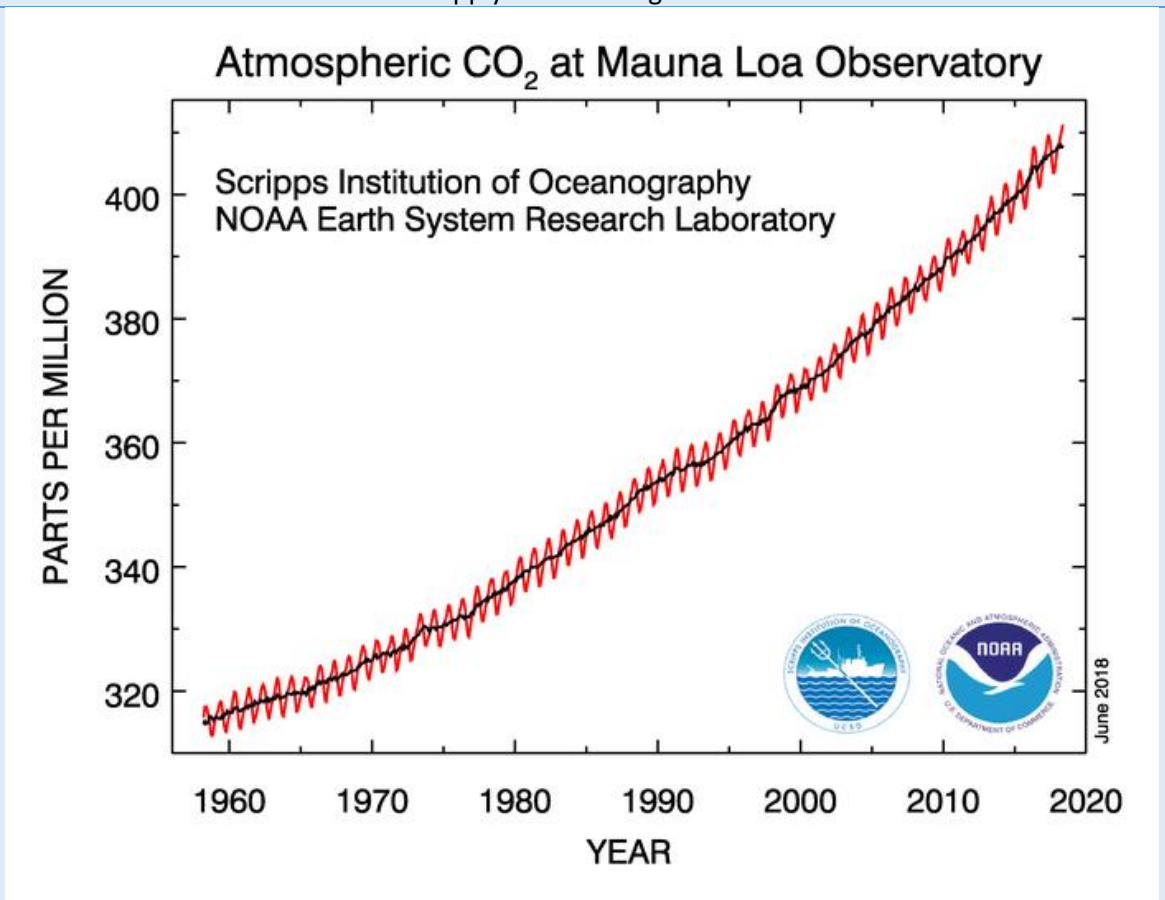
Supply chain management



CO_2 concentration in the atmosphere
https://www.esrl.noaa.gov/gmd/ccgg/trends/full.html

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Part D: Pre-module preparation

D.1. Background information

D.1.1. Introduction to logistics and supply chain management

Logistics and supply chains are all around us and are not new ideas. From the building of the pyramids and the Parthenon to the Second World War there has been little change to the principles underpinning the effective flow of materials and information to meet the requirements of customers. Throughout the history of mankind, wars have been won and lost through logistics strengths and capabilities, or the lack of them. Both logistics and supply chain management (SCM) are fascinating and exciting areas that touch all of our lives. Just think of the many different products that are purchased and consumed each day, how do they reach the customer and at what cost? Everything that we wear, that we eat, that we touch, or use every day was part of some supply chain to transform raw material from some other location into a finished product that you're enjoying now. Supply chains literally connect the world.

Supply chain management is the art and science of getting products from where they're made to where you the consumer want them to be. It's how the pair of shoes you ordered online is manufactured in Italy and sent to your front door in Kuala Lumpur, Malaysia. It's how the pears from Chile get your supermarket in Winnipeg, Canada in the winter. It's how your smartphone was assembled with more than 100 parts from over a dozen different countries. It's not just about moving stuff around. Service industries like restaurants, tourism, and health care have some of the most sophisticated supply chains. You can think of supply chain management as managing three flows:

- the flow the physical product
- the flow of information
- the flow of money.

It also deals with a reverse flow of products at the end of their life for recycling, re-manufacturing or disposal. Although logistics and SCM are areas that have only come to widespread prominence in the last two decades or so, the reality is that they have roots which run much longer than that. While the term itself, supply chain management, wasn't coined until the 1980s, the art and science of logistics dates back to ancient Roman times. It is only in the recent past that organizations have come to recognize the vital impact the logistics and supply chain management can have in the achievement of competitive advantage.

The word 'logistics' goes back to its original military application in ancient Roman and Byzantine times. One of the first references in the academic literature to the notion of taking a supply chain view (although that specific term was not used) is in what is widely regarded as a seminal paper by the MIT academic Jay Forrester published in the Harvard Business Review in 1958. In that paper, Forrester put forward a schematic of the production-distribution system (what we would call today a supply chain) and he simulated how inventory levels can fluctuate along that chain.

Logistics and SCM combines both theory and practice. You need to master these theoretical concepts but also be able to temper them with practical considerations. So supply chain management is a hybrid area that combines different disciplines, methods, and ideas. Supply chain management is the backbone of the global economy. The need for professionals who can design, manage, and operate these complex global supply chains, continues to grow.

Not only are logistics and SCM key aspects of today's business world, but they are also of importance in the not-for-profit and public sectors. In addition, while the origins of much logistics thinking and practice are in a manufacturing context, we are witnessing increased and highly

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successful application of logistics and SCM principles in a services context also (just think of the efficiencies which have been driven into many service-based activities such as banking and hospitals where the emphasis has shifted to serving more customers, better, faster, cheaper).

D.1.2. What is logistics?

The terms logistics and SCM, although often used interchangeably, are distinct. The New Oxford Dictionary of English defines logistics as: “the detailed coordination of a complex operation involving many people, facilities, or supplies. Origin late 19th century in the sense 'movement and supplying of troops and equipment', from French logistique, from loger lodge”. There are various views with regard to the linguistic origins of the word, with some pointing to the Greek adjective logistikos which means 'skilled in calculating' (and which most likely gave us the mathematical term logistic). It has also been noted that in Roman and Byzantine times there was a military official called Logista. In more recent times we have seen, as in the above definition, the French words logistique and loger. Most agree that the word entered the English language in the 19th century, with its application generally seen in military terms and concerned with the organization of moving, lodging and supplying troops and equipment.

These origins suggest then that logistics has something to do with applications of mathematics and is primarily a military concern. Indeed the field of military logistics has evolved quite considerably and is now quite sophisticated. Similarly, there are many useful applications of mathematics to logistics. Today, however, logistics spans beyond the military and mathematical domains. It was in fact only in the latter decades of the 20th century that the term logistics entered into common non-military use. The US based Council of Supply Chain Management Professionals (www.cscmp.org) suggests the following definition of logistics:

Logistics is the process of planning, implementing, and controlling procedures for the efficient and effective transportation and storage of goods including services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements. This definition includes inbound, outbound, internal, and external movements. In other words, logistics involves getting:

- the right product
- in the right way (i.e., in such a way as to cause as little damage as possible to the environment)
- in the right quantity and right quality
- in the right place at the right time
- for the right customer at the right cost

Ultimately, the mission of logistics is to serve customers in the most cost-effective way.

D.1.3. What is supply chain?

The **supply chain** is the network of organizations that are involved, through **upstream** (supplier end of the supply chain) and **downstream** (customer end of the supply chain) linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer. A **supply chain** could more accurately be defined as **a network of connected and interdependent organizations mutually and co-operatively working together to control, manage and improve the flow of materials and information from suppliers to end users**.

The supply chain is a much wider, intercompany, boundary-spanning concept, than is the case with logistics.

Supply chains encompass a number of key flows:

- Physical flows of materials

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- Flows of information that inform the supply chain
- Resources (especially finance, but also others such as people and equipment) which help the supply chain to operate effectively. Furthermore, not all resources in the supply chain are tangible, for example good quality intercompany relationships are often cited as a highly important ingredient of effective supply chains.

D.1.4. What is supply chain management?

The term supply chain management (SCM) was originally introduced by consultants in the early 1980s and, since then, has received considerable attention. **Supply chain management** (SCM) is the management, across and within a network of upstream and downstream organizations, of both relationships and flows of material, information and resources. The purposes of SCM are to create value, enhance efficiency, and satisfy customers.

According to another definition: SCM is the management of a network of relationships within a firm and between interdependent organizations and business units consisting of material suppliers, purchasing, production facilities, logistics, marketing, and related systems that facilitate the forward and reverse flow of materials, services, finances and information from the original producer to final customer with the benefits of adding value, maximizing profitability through efficiencies and achieving customer satisfaction.

An important feature to note with regard to SCM is that it involves taking an 'end-to-end' perspective from the upstream to the downstream end of the supply chain. Depending upon the sector being looked at, terminology such as the following can be used to describe the end-to-end supply chain:

- Farm to fork
- Sketch to store
- Dust to rust

A final important point to note at this juncture is that increasingly it is the case that supply chains compete more so than individual firms and products. This represents something of a paradigm shift in terms of how people usually view the global business environment.

D.1.5. Distinguishing logistics and SCM

Supply chain management is a wider concept than logistics. In fact, logistics is part of the wider entity which is SCM. The supply chain is a much wider, intercompany, boundary-spanning concept, than is the case with logistics. Logistics is essentially a planning orientation and framework that seeks to create a single plan for the flow of products and information through a business. Supply chain management builds upon this framework and seeks to achieve linkage and co-ordination between the processes of other entities in the pipeline, i.e. suppliers and customers, and the organization itself. The focus of supply chain management is on co-operation and trust and the recognition that, properly managed, the 'whole can be greater than the sum of its parts'. Thus the focus of supply chain management is upon the management of relationships in order to achieve a more profitable outcome for all parties in the chain.

Whilst the phrase 'supply chain management' is now widely used, it could be argued that 'demand chain management' would be more appropriate, to reflect the fact that the chain should be driven by the market, not by suppliers. Equally, the word 'chain' should be replaced by 'network' as there will normally be multiple suppliers and, indeed, suppliers to suppliers as well as multiple customers and customers' customers to be included in the total system.

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D.1.6. Competitive advantage

Effective logistics and supply chain management can provide a major source of competitive advantage - in other words, a position of enduring superiority over competitors in terms of customer preference may be achieved through better management of logistics and the supply chain.

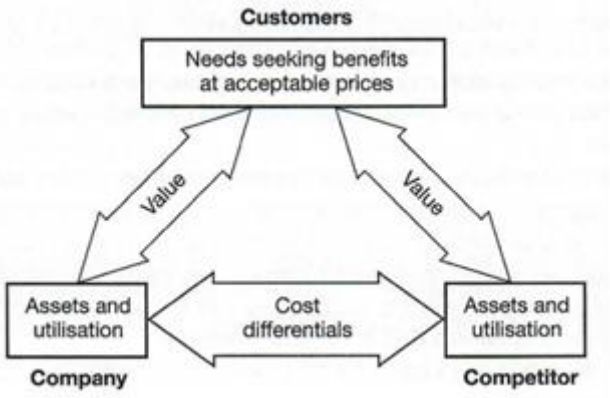

Figure 1. Competitive advantage and the 'Three Cs'

The source of competitive advantage is found firstly in the ability of the organization to differentiate itself positively, in the eyes of the customer, from its competition, and secondly by operating at a lower cost and hence at greater profit. Seeking a sustainable and defensible competitive advantage has become the concern of every manager who is alert to the realities of the marketplace. It is no longer acceptable to assume that good products will sell themselves, neither is it advisable to imagine that success today will carry forward into tomorrow.

Let us consider the bases of success in any competitive context. At its most elemental, commercial success derives from either a cost advantage or a value advantage or, ideally, both. It is as simple as that - the most profitable competitor in any industry sector tends to be the lowest-cost producer or the supplier providing a product with the greatest perceived differentiated values. Put very simply, successful companies either have a cost advantage or they have a value advantage, or - even better - a combination of the two. Cost advantage gives a lower cost profile and the value advantage gives the product or offering a differential 'plus' over competitive offerings.

D.1.7. Cost advantage

In many industries there will typically be one competitor who will be the low-cost producer and often that competitor will have the greatest sales volume in the sector. There is substantial evidence to suggest that 'big is beautiful' when it comes to cost advantage. This is partly due to economies of scale, which enable fixed costs to be spread over a greater volume, but more particularly to the impact of the 'experience curve'.

The **experience curve** is a graphical representation of the phenomenon explained in the mid-1960s by Bruce D. Henderson, founder of the Boston Consulting Group. It refers to the effect that firms learn from doing, which means that the higher the cumulative volume of production (X), the lower the direct cost per new unit produced (C). Therefore, the experience curve will be convex and have a downward slope, as shown in Figure 2.

There is a simple rationalization behind all this: there is a reduction in the average cost of production of a particular product, as a consequence of an increase in the firm’s experience. The time and cost of producing a unit of output will be reduced, as learning economies, economies of

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scale, economies of scope, etc. appear due to the cumulative output increase and other process related growth.

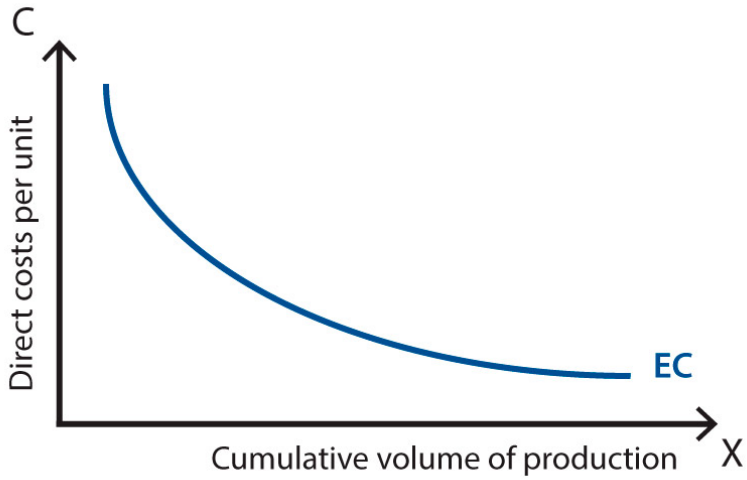

Figure 2. The experience curve.

D.1.8. Creating a sustainable supply chain

Perhaps one of the biggest issues to rise to prominence across every aspect of business and society in the opening years of the twenty-first century has been **sustainability**. The growing concern with the environment, in particular the possibility of climate change through global warming, has led to a focus on how human and economic activity has the potential to adversely impact the long-term sustainability of the planet.

The definition of sustainability that is most widely used originates from the United Nations Brundtland Commission which reported in 1987. **Sustainability**, the Commission suggested, was about **meeting the needs of the present without compromising the ability of future generations to meet their own needs**.

Sustainable logistics is concerned with reducing the environmental and other dis-benefits associated with the movement of freight. Sustainability seeks to ensure that decisions made today do not have an adverse impact upon future generations. Sustainable supply chains seek to reduce these dis-benefits by inter alia redesigning sourcing and distribution systems so as to eliminate any inefficiencies and unnecessary freight movements.

Often, people regard sustainability as just referring to 'green' issues. This, however, is just one (albeit very important) dimension and we have also to consider the issue of **economic sustainability**, i.e. how can the firm itself survive and grow in a sustainable manner without having adverse impacts on future generations, and specifically what is the role of logistics and SCM in this context. The term sustainability has been used to include 'environmental management, closed-loop supply chains and a broad perspective on triple-bottom-line (3BL) thinking, integrating profit, people and the planet into the culture, strategy and operations of companies.'

This definition can be further augmented by adopting the parallel idea of the '**triple bottom line**'. The triple bottom line concept emphasizes the importance of examining the impact of business decisions on three key arenas:

- Environment: For example, pollution; climate change; the depletion of scarce resources, etc.
- Economy: For example, the effect on people's livelihoods and financial security; the profitability of the business, etc.

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- Society: For example, the reduction of poverty; the improvement of working and living conditions, etc.

These three elements - the 3Ps of People, Profit and Planet - are inevitably intertwined and they serve to remind us that for a business to be truly sustainable, it must pay regard to the wider impact of the activities it undertakes if it seeks to remain viable and profitable.

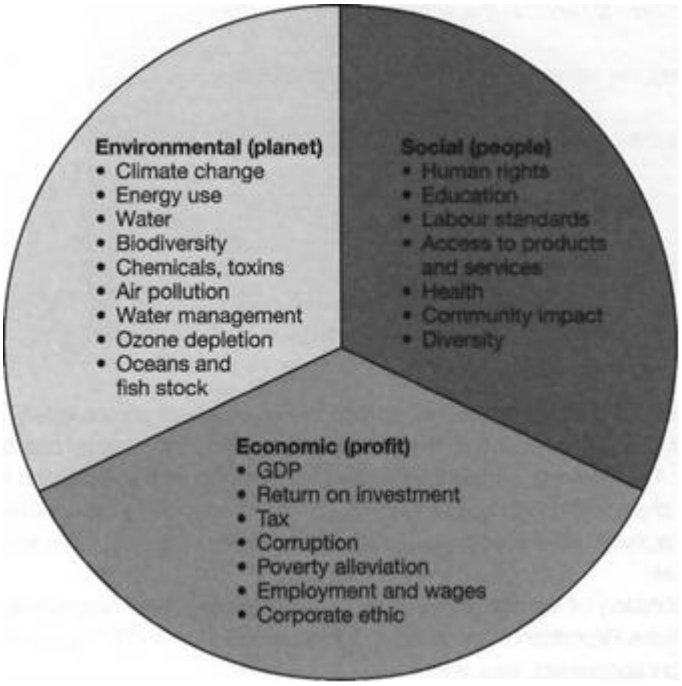

Figure 3. The triple bottom line: planet, people, profit.

In the context of supply chains we can build on the triple bottom line philosophy to encompass the wider idea that sustainability is concerned with ensuring the long-term viability and continuity of the business as well as contributing to the future well-being of society. Indeed, it can be argued that these two goals are mutually supportive, i.e. supply chain strategies that benefit the wider environment are likely also to involve the business in less cost in the long-term as the result of a better use of resources. For example, one element in a 'green' supply chain might involve utilizing transport capacity more efficiently through better routing and scheduling. In so doing, not only is the environmental impact of transport reduced, but also the cost to the company.

Because the supply chain underpins the efficient and effective running of the business, it can provide a useful framework for exploring opportunities for improving sustainability. If we adopt the philosophy stating that the supply chain 'begins on the drawing board' (i.e., that product design decisions impact subsequent supply chain costs), it makes sense to look at sustainability across the entire product life cycle. In other words, we need to understand the impact on sustainability of everything we do from product design through to end-of-life disposal.

D.1.9. The “green revolution” and supply chain redesign

Recent years have seen a dramatic increase in what have come to be known as 'green' issues, which can generally be regarded as encompassing respect for the world's natural environment (including its atmosphere) so as to ensure that actions taken today do not hinder future generations. A key concern centers in particular around the use of fossil fuels for power generation and the resultant carbon emissions. The international Kyoto Protocol has called for a 60%

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reduction in carbon emissions by 2050. This is a steep target with many commentators pessimistic it will ever be achieved. 'Emissions trading' has now come into fashion whereby companies and countries engage in environmentally positive activities (for example planting trees) in order to offset the deleterious effects of carbon emissions.

D.1.10. Greenhouse gases and the supply chain

Recent years have seen a considerable growth of awareness of the potential harm to the environment that can be caused by so-called '**greenhouse gases**'. These gases include carbon dioxide, methane and nitrous oxide and various fluorocarbons. Generically these emissions as they relate to an activity are often referred to as its '**carbon footprint**'. The term carbon footprint has come into use to describe the environmental dis-benefits associated with economic activities such as the movement of freight As a result of increased economic activity around the world, the level of these greenhouse gases has risen significantly over the years. It is estimated that current levels are around 410 parts per million compared to 280 parts per million before the Industrial Revolution.

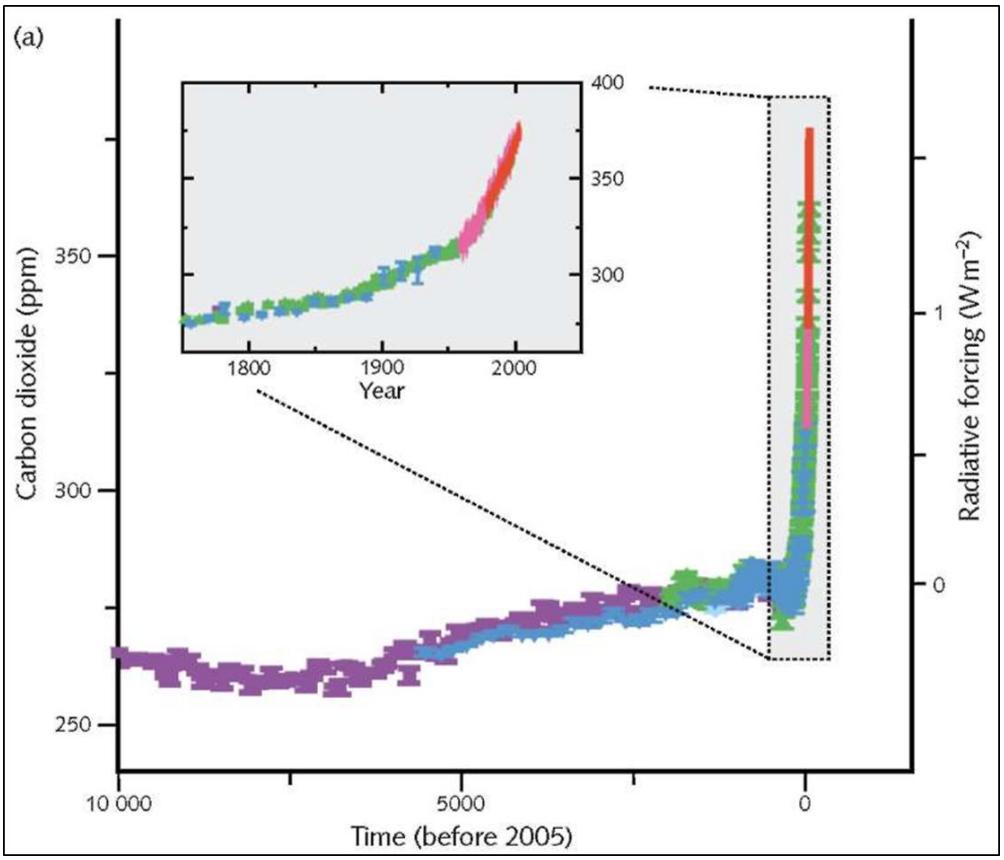

Figure 4. CO_2 concentration in the Earth's atmosphere in the last 10000 years.

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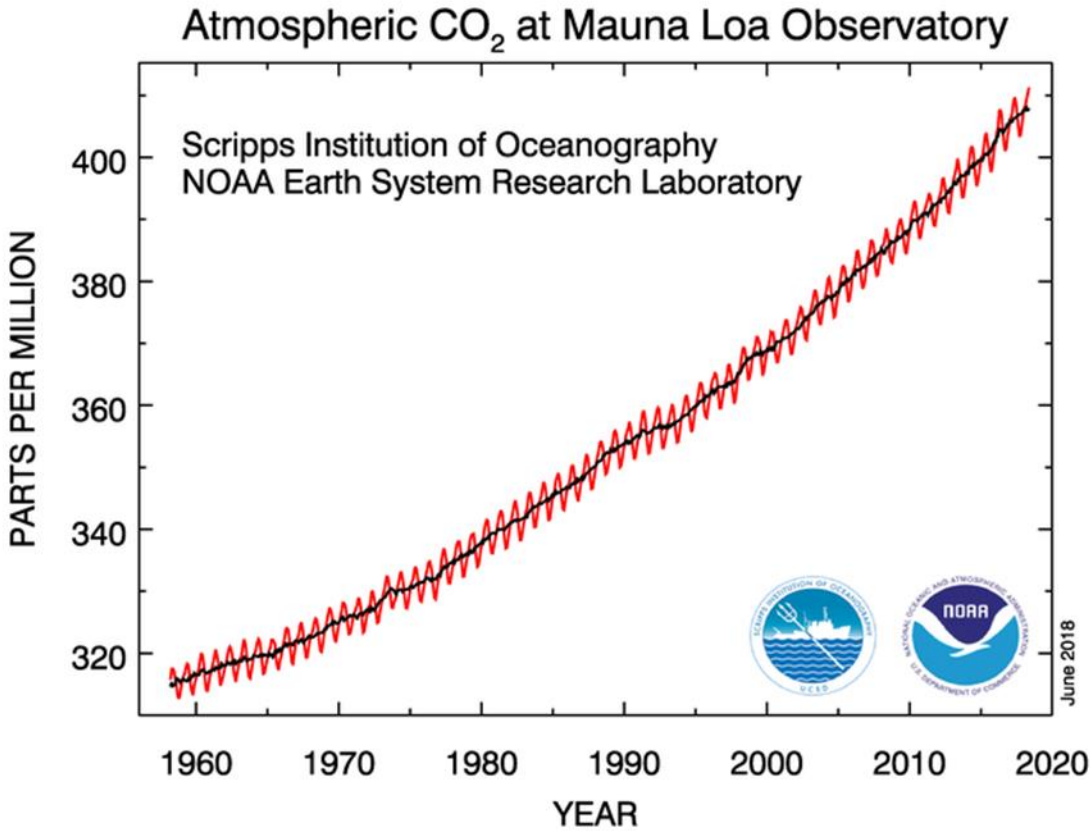

Figure 5. CO_2 concentration in the Earth's atmosphere since 1958.

Consumers are becoming increasingly aware of the impact of purchasing goods which may have been sourced over long distances. It may generally appear to be the case that such goods have a larger carbon footprint, although we would caution that this view is overly simplistic. For example if locally produced goods are manufactured and distributed in an environmentally damaging manner, then this may be worse than procuring goods from overseas which are manufactured and distributed in an environmentally sustainable manner. A good example of this are certain fruits and vegetables which grow naturally in some distant countries - and can also sometimes be grown too (but with the aid of artificial inputs) in the destination markets (thus avoiding the need for long-distance transport).

Another term that has come to be increasingly used is **food miles**: this refers to the distance over which the various components of a particular food item have to travel before final consumption. In time it may be the case that ingredients labels on foodstuffs will also include such food miles data.

D.1.11. Climate change

A view that is held by many commentators, although not all, is that this increase in greenhouse gas levels has been, and is, a major cause of climate change. A number of influential reports have brought these issues to the attention of governments, industry and the wider public on a global scale. Even though it has proved difficult to get universal agreement on the best means for reducing greenhouse gas emissions, there is a widespread acknowledgement that action is required. For supply chain managers this is a particular call to action because some of the major causes of

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greenhouse gases arise from industrial activities such as manufacturing, energy production and transportation. In the specific case of freight transport, for example, it is acknowledged that as a result of the globalization of supply chains we are now moving products greater distances than ever before with a consequent impact on the carbon footprint. For example, it is estimated that the approximately 400 different components in a laptop computer had travelled hundreds of thousands of miles from all their different sources and through the assembly and distribution process to reach the customer. In recent years there has been a growing awareness amongst consumers of the issue of 'food miles' - in other words how far food travels from its origin to the point of final consumption - and what the impact of this might be on carbon emissions. Whilst at the moment the environmental costs incurred as a result of commercial activity are not generally borne by the companies that cause them, this will almost certainly change as a result of carbon taxes, emission trading schemes and regulatory change. Hence the need for supply chain managers to be thinking hard about alternative strategies.

D.1.12. Reducing the transport-intensity of supply chains

As global economic growth continues, so too does international trade increase and hence transport. The continued upward trend in global sourcing has inevitably led to products travelling greater distances. Increased outsourcing and offshoring to lower cost locations have generated huge flows of international freight. The end result is an increase in what might be termed the transport-intensity of the supply chain. Transport-intensity can be measured in a number of ways, but at its simplest it is a reflection of the miles or km travelled per unit of product shipped. As the transport of raw material and finished goods globally is estimated to consume 15 million barrels of oil each day - almost one-fifth of the world's daily production - there is clearly a correlation between transport-intensity and a supply chain's carbon footprint. Not only is there an economic benefit to be gained by improving transport-intensity but also a potential positive environmental impact - this is the concept of eco-efficiency which is rapidly becoming a major issue in global commerce.

It is important to also note that the movement of freight is not responsible for all of the environmental dis-benefits associated with transportation: the movement of people also creates dis-benefits and some logisticians argue that freight takes an unfair share of the blame!

What practical steps can organizations take to improve the transport-intensity of their supply chains?

- **Review product design and bill of materials**

Product design can impact transport-intensity through the physical characteristics of the product, its density, the choice of materials (including packaging materials), the ease of re-cycling and re-use and end-of-life disposal.

- **Review sourcing strategy**

Many sourcing decisions have led to a migration to low-cost country locations. This often has led to products being moved greater distances.

- **Review transport options**

Clearly different transport modes have different impacts on carbon and other emissions. The design of vehicles and vessels is also increasingly influenced by the need to improve fuel efficiency. There are also arguments for increasing the size of vehicle or the vessel to achieve lower transport-intensity per unit. For example, new generation container ships such as the Orient Overseas Container Line (http://www.oocl.com) class of vessels.

- **Improve transport utilization**

Research has highlighted that often vehicle capacity is poorly utilized. It is suggested that empty running because of the lack of return loads means that up to a third of the trucks on the roads of

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Europe are running empty! More use of shared distribution, better vehicle routing and scheduling and better loading can also dramatically improve transport-intensity.

- **Use postponement strategies**

If standard, generic products can be shipped in bulk from their point of origin and then assembled, customized or configured for local requirements nearer the point-of-use, there may be an opportunity to reduce overall transport-intensity.

A further incentive to reduce the transport-intensity arises from the continued upward pressure on oil-based fuel costs which will only intensify as oil reserves become depleted.

D.1.13. How green is your supply chain?

It is difficult to know exactly how green a supply chain actually is - established industry standards don't yet exist. However, there is emerging agreement at least with regard to how best to measure carbon footprints (see, for example, the Carbon Trust: www.carbontrust.com); in addition, with regard specifically to transport, the EU has now published a methodology for the calculation and declaration of energy consumption and GHG emissions of transport services (see the British Standards Institution BS EN 16258: 2012).

There are in effect **three ways** in which to **improve the sustainability of logistics and supply chain systems**:

- **Redesigning** supply chains
- Using **scale** to reduce the negative environmental effects of logistics activities (i.e. by moving freight in larger single loads, thus cutting down on both unit costs and dis-benefits)
- Similarly promoting various **efficiency** solutions (by transporting and handling freight more effectively)

It is important to note that these three solutions are not mutually exclusive: a smart, environmentally sensitive supply chain will combine all three.

Redesigning supply chains

It is widely accepted that greening a supply chain is largely about forward planning, with some commentators noting that over 80% of carbon savings are only achievable at the supply chain design stage. While various initiatives such as, for example, switching to hybrid fuel vehicles are obviously welcome, and generate publicity benefits for companies, it is the (often unnoticed in the public eye) supply chain design decisions, such as deciding where to locate warehouses and distribution centers and which transport modes to use, that have the greatest impact.

Short-sea shipping where goods are increasingly moved over short sea routes (a more environmentally friendly mode of transport) rather than along congested (and environmentally more harmful) roads, is becoming increasingly popular. Yet even with this positive development some difficulties have emerged. In some parts of the world, particularly near coasts and populated areas, Sulphur Emission Control Areas (SECAs) have been established to ensure ships burn cleaner fuels (i.e. less sulphur). A consequence of this is that ships have to use more expensive fuel for some parts of their journey, with the implication that road transport alternatives may be economically more viable but more environmentally damaging.

Other examples of sustainable supply chain redesigns include reconfiguring distribution networks so as to replace small deliveries direct to all end customers with centralized deliveries to a hub from where end customers retrieve their goods. London's Heathrow Airport for example has developed a retail consolidation center adjacent to the airport which receives deliveries on behalf of the various retailers within the airport. Deliveries from different suppliers for these retailers can then be grouped together and delivered to the retailers. The key principle at play here is that it is, other things being equal, more environmentally sustainable when freight moves in bulk as far

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downstream as possible; conversely we can envisage a delivery truck with a small consignment going to a single customer as having relatively high environmental costs.

A possibly more environmentally friendly scenario is local sourcing. One should not, however, underestimate the role of the various factors we discussed with regard to outsourcing and offshoring (such as cheaper labor and materials costs), combined with the fact that many companies have made substantial investments in overseas lower cost locations, which they will want to recoup. These factors can thus still render locally sourced goods more expensive. The key then is to ensure that if goods are sourced overseas, that this is done in an environmentally sustainable manner. Furthermore, as many businesses have profit as their primary objective, the key is to ensure that they see the business benefits of environmentally sustainable activities, which may include for example reduced energy bills and enhanced consumer loyalty (although we know that there is a limit to how much more customers will be willing to pay for goods with a low carbon footprint).

The role of scale in logistics and SCM

One of the biggest global shipping and logistics company is A.P. Moller- Maersk (https://www.maerskline.com). Established in Denmark in 1904, today the group employs roughly 76.000 people in some 130 countries. The group's shipping subsidiaries operate some of the world's largest container vessels. One of Maersk's larger vessels, with a capacity of some 14.700 TEU (twenty-foot equivalent units), the Emma Maersk, won the title of ship of the year at the 2007 Lloyd's List awards. The ship is a quarter of a mile long, 200 feet high and as wide as a motorway. And it can be operated by a crew of just 13. More recently, Maersk took delivery of larger vessels with a capacity of up to 18,000 TEU (see the dedicated website on this initiative: www.worldslargestship.com). They are labeled 'Triple-E' (the three Es being: energy efficiency, economy of scale and the environment) and Maersk states that these giants will reduce CO_2 emissions by more than 35% per container moved. According to A.P. Moller - Maersk:

- If all the containers in the world were lined up, it would create a container wall with a length of 108,000 kilometres: a third of the way to the moon!
- The volume of freight that can be held in one standard 40 foot container is quite significant: 200 dishwashers, 350 bicycles or 5000 pairs of jeans.
- The shipping cost per unit is thus quite low: Maersk estimates, for freight coming from Asia to Europe, it costs £9 per dishwasher, £5 per bicycle and just £0.35 per pair of jeans.

Only certain ports can handle such ultra large vessels like the Emma Maersk, however, and many container vessels in routine operation are much smaller than this. With fewer ports able to handle larger vessels, there is growing traffic concentration at certain ports. Increasingly, many mid-sized ports are playing a feeder role to the very large ports as hub and spoke networks have emerged. In these networks the larger vessels ply between the major transshipment hubs, with the result that the prosperity of the smaller ports is increasingly dependent on the route strategies of the major shipping lines. This then is the impact of increasing scale on global shipping and port operations. Regardless of the impact of these developments on ports and shipping, important as they are, the question we need to address is: are these patterns of trade sustainable going forward?

Given the increasingly integrated nature of the global economy, some commentators argue that such developments are both inevitable and necessary. Others argue that the frequent movement of low-value products around the world is unnecessary, deleterious to the environment, and not sustainable in the long term. A cursory analysis of the Moller - Maersk figures quoted above, however, shows that container shipping costs are only a fraction of end-product value; unless there is a dramatic rebalancing between regions of other costs in the global economy (such as raw materials and labor costs) it is likely that these patterns of trade are set to continue. If they are, our concern from a logistics standpoint must be how to facilitate them while reducing as much as possible their negative consequences on the environment.

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Many commentators believe the solution to environmental sustainability and social responsibility issues lies in the 'downscaling, decentralizing and deconsolidating of supply chains and logistics systems'. However, they challenge this and, using research on the food supply chain, suggest that 'environmental burden actually decreases across increasing logistical scale and supply chain sophistication'.

Efficiency solutions

As well as looking to increased scale, many logistics operators are also seeking efficiencies with how they move and store freight so as to reduce the environmental impact of their activities. The 'Port-centric logistics' case study gives insights into how for example logistics companies are seeking to reduce unnecessary road haulage movements for imported maritime freight, and in turn reducing the carbon footprint of such freight movements.

The following list gives some of the many ways in which logistics efficiencies can be generated and simultaneous environmental penalties reduced, in the case of road haulage (http://www.freightbestpractice.org.uk):

- Reducing empty running, pooling and sharing capacity, obtaining 'backhaul' loads (a number of websites have been developed which match carriers who have available capacity with shippers seeking capacity
- Increasing vehicle payload capacity (by weight and/or by cubic volume) - double deck and higher trailers, single tractor unit and multiple trailer combinations, etc.
- Improved vehicle routing using GPS and other systems
- More efficient use of packaging and loading of containers
- Improved vehicle driving (in-cab computer monitoring of driving style, even examining the benefits of air conditioning versus open windows!)
- Enhancing vehicle operating efficiency (for example using hybrid fuels, ensuring correct wheel alignment and enhanced aerodynamic styling of trucks)

The issue of supply chain strategy can impact the efficiency of the transport services demanded, with Just in Time (JIT) strategies for example leading to inefficient transport utilization with frequent small loads. Whether JIT systems are sustainable from an environmental perspective going forward is an important question.

In transportation, it is not just the road haulage sector that is seeking to reduce its environmental footprint. With the growth of air travel, spurred on in particular by rapid growth in the so-called low fares category of air travel, many commentators are looking towards the air transport sector to reduce its impact on the environment. The leading aircraft manufacturers are all moving towards aircraft designs that use lighter materials and are more fuel efficient. Similar developments are taking place in shipping, both in terms of vessel hull design and propulsion technologies.

In logistics, efficiency solutions are not just restricted to transportation. The area of green warehouse design is also growing in popularity. Many warehouses are vast structures and their environmental footprints can be reduced by, for example, more efficient lighting and heating/refrigeration systems.

D.1.14. Reduce, re-use, re-cycle

The 3Rs of sustainable supply chain management - reduce, re-use and re-cycle - are now starting to receive much more attention in most companies today. There is a growing realization that not only is a strategy focused on improving the environmental impact of economic activity good for all who live on this planet, but because such strategies consume fewer resources the overall profitability of the business should also improve.

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Many companies are now actively seeking to create marketing strategies that emphasize the 'greenness' of their supply chains. Whilst the more cynical observers may dismiss these moves as opportunism - what some have dubbed 'green"-wash' - there can be no questions that customers and consumers in markets around the world are starting to demand that suppliers reduce their various footprints.

Strong evidence is emerging that consumers are increasingly basing their purchasing behavior on ethical and environmental criteria. In some instances, major retailers such as Wal-Mart and Tesco are seeking to improve their supply chain footprints and are demanding action from their supplier to improve their performance on the 3Rs, i.e. to demonstrate how they are reducing the use of materials such as packaging and how they are designing products that can be re-used or re-cycled. Both Wal-Mart and Tesco (and other retailers too) intend to provide information on the labels of the products they sell detailing the overall environmental impact of those items. To do this they are working closely with their suppliers to ensure that their supply chain arrangements are sustainable and that they continue to seek innovative ways to improve the end-to-end environmental footprint.

For example, Tesco recognized that glass bottles, because of their weight, add significantly to transport-intensity and overall carbon emission. By working with suppliers to create lighter weight wine bottles Tesco reduced its annual glass usage from one single supplier by 2,600 tonnes - a 15 per cent saving. Further savings were achieved by importing wines into the UK from Australia in bulk and then bottling them in lightweight glass in the UK.

Further pressure on businesses to reduce their environmental footprints is coming from government regulations, often in the form of emissions trading schemes or so-called 'cap and trade' legislation. For example, the European Union's Emissions Trading Scheme has been extended to cover a greater range of industries and is based on the principle that companies have a basic allowance for carbon emissions - if they go beyond that level they have to buy additional allowance from other companies who do not fully use their own. Similar schemes are currently contemplated by governments around the world and in time their impact is likely to be significant. As, as we have noted, most of a typical business's total environmental footprint lies in its wider supply chain, particularly upstream of its own operations, the need for supply chain managers to become more involved in managing this footprint becomes apparent.

D.2. Case studies

D.2.1. Case study #1: 'Plan A' at Marks and Spencer

Marks and Spencer (M&S) is one of the UK's biggest and longest-established retailers, with a focus on clothing, food and homeware. In 2007, the then chief executive, Stuart Rose, announced a bold strategy to build a more environmentally and socially sustainable business. It was termed 'Plan A because, as Stuart Rose stated, there was no Plan B. The emphasis in Plan A is on cutting waste, sourcing ethically, saving energy and developing a company-wide ethos of social responsibility. The impact of Plan A has been felt right across the company's supply chain from their sourcing strategy to the design of retail outlets. Plan A is constantly under review as new targets for sustainability are set.

Whilst such an initiative inevitably doesn't come cheap, the company believes that it has saved money as a result. In 2012, M&S established that they had saved £135m as a result of Plan A actions, up from £105m in the previous year. These savings had come from installing low-energy lighting and more efficient refrigerators, landfill waste reduced to zero, reduced water use and other sources.

More than the cost of savings though was the impact on the impressions of the company stakeholders. Chief Executive Marc Bollard when interviewed about the impact of Plan A stressed

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that 'long-term investors are interested in a sustainable business fuelled by the values behind Plan A. Shoppers assailed in recent months by headlines over the source of their products, like the idea that they don't have to worry if they are ethically sourced or that workers are treated well in the factories supplying M&S'.
Source: https://corporate.marksandspencer.com/plan-a

D.2.2. Case study #2: Measuring the Carbon Footprint

Greenhouse gas (GHG) emissions are those that contribute to climate change, with most (approximately 95%) being in the form of carbon dioxide, which results from, among other activities, the burning of fossil fuels. Various entities have developed guides on how to measure and report GHG emissions. In the UK, for example, Defra (the UK government department responsible for the environment, food and rural affairs) has produced a guide for measuring and reporting GHG emissions from freight transport (https://www.gov.uk/guidance/measuring-and-reporting-environmental-impacts-guidance-for-businesses). Detailed guidelines and look-up tables are available online but in essence the calculation comprises:

$kgCO_2eq$ = (Fuel used) × (The appropriate emission factor for the type of fuel used)

Note: 'eq' refers to 'equivalent' as this also captures other gases such as methane and nitrous oxide.

Figure 6 illustrates carbon footprint data for a real life study of container movements from the Middle East to the UK. Three route options were available, two involving deep-sea transport to Continental Europe and then transshipment via Antwerp (Lo-Lo) or Zeebrugge (Ro-Ro), plus a direct deep-sea transport option direct to the UK. The diagram illustrates the carbon footprint for the different transport-related activities in the end-to-end chain. What is striking from the data is the relatively large carbon footprint incurred by the relatively short feeder journeys between Continental Europe and the UK (the shaded boxes with black surrounds towards the top of the first two bars). In fact, our analysis suggested that end-to-end logistics-related carbon emissions could be reduced by 16-21% through direct delivery to the UK as opposed to transshipment via a Continental European port.

Moving beyond transport, the challenge is to conduct carbon auditing of whole supply chains at the product level. Research led by Professor Alan McKinnon (one of the world's leading experts in the areas of logistics, transport and the environment) has concluded, however, that product-level carbon auditing and labeling is a 'wasteful distraction' and that it would be better to devote management time and resources to other de-carbonization initiatives.

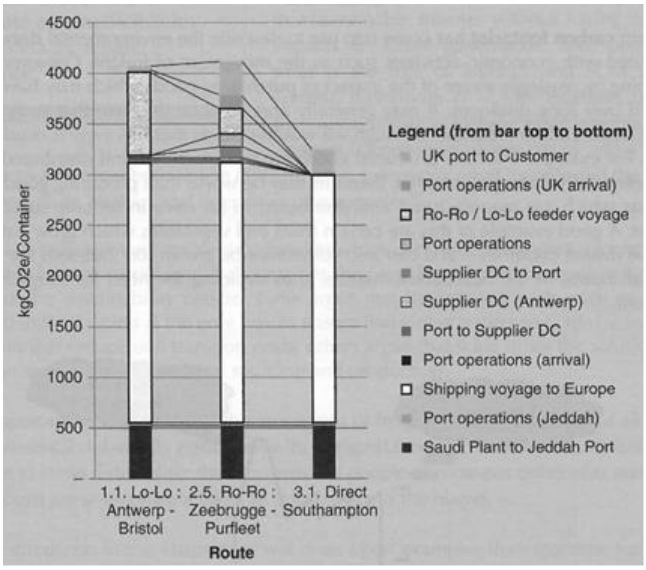

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Figure 6. Carbon footprint for a container journey (three alternative routings).

Sources:

1. Rigot-Muller, P., Lalwani, C, Mangan, J., Gregory, O. & Gibbs, D. (2013) Optimizing end-to-end maritime supply chains: A carbon footprint perspective. International Journal of Logistics Management, 24(3), 407-425. https://doi.org/10.1108/IJLM-01-2013-0002
2. http://www.alanmckinnon.co.uk/

D.2.3. Case study #3: IKEA

The Swedish retailer Ikea has long been regarded as a very environmentally conscious company and these initiatives were part of many wider efforts to evidence the company's commitment to sustainability and are detailed in its 'Social and Environmental Responsibility' report. One example is where IKEA worked with a supplier to reduce by 1 cm a package containing a sofa from 91 cm wide to 90 cm. As a result, four extra sofas could be fitted onto each trailer, with obvious cost and environmental benefits.

Source:

https://www.ikea.com/ms/en_JP/customer_service/faq/help/about_ikea/social_environment.html#1.

D.2.4. Case study #4: DHL Corporate Responsibility and GoGreen

With 'Living Responsibility' as its motto, DHL focuses on environmental protection (GoGreen), disaster management (GoHelp) and education (GoTeach) and supports employee volunteerism (Global Volunteer Day, Living Responsibility Fund). With GoGreen, the company has a climate protection target which calls for improving its carbon efficiency by 30% over the 2007 baseline by the year 2020. In an effort to reach that target, DHL has developed and implemented measures to improve the carbon efficiency of its air and road transport operations as well as that of its buildings and facilities.

Sources:

DHL Corporate Responsibility, http://www.dhl.com/en/about_us/responsibility.html

DHL GoGreen, https://www.dpdhl.com/en/responsibility/environment-and-solutions.html and http://www.dhl.com/en/about_us/green_solutions.html

D.2.5. Additional case studies

More similar case studies can be found in the Carbon Disclosure Project (https://www.cdp.net/en).

D.3. Resources

The following list provides the sources of information that engineers may refer for enchasing their knowledge in Logistics and Supply Chain Management, as well as to CO_2 emissions in the atmosphere and global warming.

D.3.1. Books

- Κλιματική αλλαγή, Διαχείριση της Εφοδιαστικής Αλυσίδας και Προσαρμογή των Επιχειρήσεων, Συγγραφέας: Κώστας Π. Παππής, Εκδόσεις Επίκεντρο, 2011, ISBN: 978-960-458-269-3.
- Global Logistics and Supply Chain Management, Authors: J. Mangan and C.L. Lalwani, John Wiley & Sons, 3rd Edition, 2016, ISBN: 978-111-911-782-7.

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- Logistics και διαχείριση εφοδιαστικής αλυσίδας, Συγγραφέας: M. Christopher, Εκδόσεις Κριτική, 2η έκδοση, 2017, ISBN: 978-960-586-187-2.
- Logistics and Supply Chain Management, Author: M. Christopher, FT Publishing International, 5th edition, 2016, ISBN: 978-129-208-379-7.
- Διοίκηση Λειτουργιών και Εφοδιαστικής Αλυσίδας, Συγγραφείς: F.R. Jacobs and R.B. Chase, Εκδόσεις BROKEN HILL PUBLISHERS LTD, 2011, ISBN: 978-960-489-149-8.
- Operations and Supply Chain Management, Authors: F.R. Jacobs and R.B. Chase, McGraw-Hill Education, 15th edition, International student edition, 2017, ISBN: 978-125-992-179-7.
- Διοίκηση Εφοδιαστικής Αλυσίδας, Συγγραφείς: S. Chopra and P. Meindl, ΕΚΔΟΣΕΙΣ Α. ΤΖΙΟΛΑ & ΥΙΟΙ Α.Ε., 5η Έκδοση, 2014, ISBN: 978-960-418-465-1.
- Οργάνωση Παραγωγής και Διοίκηση Εφοδιασμού, Συγγραφείς: R.S. Russell and B.W. Taylor, ΕΚΔΟΣΕΙΣ Α. ΤΖΙΟΛΑ & ΥΙΟΙ Α.Ε., 8η Έκδοση, 2016, ISBN: 978-960-418-557-3.
- Essentials of Supply Chain Management, by Michael H. Hugos, Wiley, 3rd Edition, 2011, ISBN: 978-047-094-218-5.
- Supply Chain Management: Strategy, Planning, and Operation, by Sunil Chopra and Peter Meindl, Pearson, 6th edition, Global Edition, 2015, ISBN: 978-129-209-356-7.
- Operations and Supply Chain Management, by Roberta S. Russell, Bernard W. Taylor, John Wiley & Sons, 8th, Edition, International Student edition, 2014, ISBN: 978-111-880-890-0.

D.3.2. Massive Open Online Courses (MOOCs)

- Supply Chain Management Specialization, Rutgers Business School, Coursera, https://www.coursera.org/specializations/supply-chain-management
- Supply Chain Management, edX, https://www.edx.org/micromasters/mitx-supply-chain-management

D.3.3. Web sites

- Council of Supply Chain Management Professionals, www.cscmp.org
- CO_2 concentration in the atmosphere, https://www.esrl.noaa.gov/gmd/ccgg/trends/full.html
- Intergovernmental Panel on Climate Change, IPCC, http://www.ipcc.ch/
- The Stern Review Report on the Economics of Climate Change, http://webarchive.nationalarchives.gov.uk/20100407172811/http://www.hm-treasury.gov.uk/stern_review_report.htm
- The Carbon Disclosure Project, https://www.cdp.net/en
- Web sites for the calculation of CO_2 emissions
  - http://carbonfund.org/how-we-calculate/
  - https://www.carbonfootprint.com/
  - https://www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx
  - http://ecoscore.be/en/info/ecoscore/co2
  - https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator
  - https://www.eea.europa.eu/highlights/co2-emissions-calculations-explaining-concepts
  - http://www.carbon-calculator.org.uk/
  - https://www.eecabusiness.govt.nz/tools/wood-energy-calculators/co2-emission-calculator/
  - https://www.co2logic.com/en/services/co2-calculator
- Supply chain and sustainability

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United Nations Global Compact, https://www.unglobalcompact.org
The Sustainable Development Goals Compass, https://sdgcompass.org/
https://www.procurious.com/procurement-news/supply-chain-sustainability-responsibility
https://www.businessgreen.com/bg/analysis/1803867/airships-float-future
https://www.rit.edu/affiliate/nysp2i/infohub/supply-chain-sustainability/overview
https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/starting-at-the-source-sustainability-in-supply-chains
https://www.rmagreen.com/rma-blog/what-is-sustainable-supply-chain-management

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Part E: Module overall presentation

E.1. Introductory presentation

Please refer to the Power Point document for the introductory presentation

E.2. Discussion questions

Can you define logistics and supply chain management using your own words?
Are logistics and supply chain management only of interest to manufacturers?
How do logistics and supply chain management differ?
What are the basic operations of the supply chain?
What is meant by the term 'Corporate Social Responsibility '?
What is meant by the term 'carbon footprint'?
What is climate change?
What are the impacts of climate change on humanity?
How climate change can affect businesses?
What are the risks faced by companies as a result of climate change?
Why it is important for businesses to reduce the environmental footprint of their supply chain?
What strategies companies can use to reduce their environmental footprint?

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Part F: Post-Module (Post-training)

F.1. Reflective questions

These reflective questions are related to the problem-based investigation. Below a set of reflective question are given which the facilitator can use in order to ask the engineers for the self-reflection phase.

1. What are the different stages of the supply chain of the product or the service you chose?
2. Which of these stages have the most significant environmental footprint?
3. Calculate (where possible) the environmental footprint of the individual stages of the supply chain.
4. Which strategies do you propose to reduce the environmental footprint of the supply chain?

F.2. The modules assessment

Each team should submit a technical report and prepare a comprehensive presentation regarding the given problem. The technical report should contain roughly the following items:

Guidelines for the technical report

1. Introduction to the product or service you have chosen.
2. Analytical presentation of its supply chain.
3. Presentation of the processes that may take place at the various stages of the supply chain.
4. Methodology for calculating the carbon footprint of the different stages of the supply chain.
5. Suggestions for strategies to reduce the carbon footprint of the supply chain.
6. Perform a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis of the proposed strategies for the reduction of the carbon footprint of the supply chain.

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