Supply Chain Carbon Management Models

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Abstract-We are constantly confronted with environmental changes across the world ranging from extreme weather to a scarcity of water for nearly 2 billion people, nearly 40% of the world's population. Such phenomena and reality has created a movement across the globe to identify the causes of global warming and develop solutions to end it before it is too late. In a effort to address the growing evidence of climate change, many nations are passing laws and regulations aimed specifically at reducing carbon emissions and greenhouse gas from the atmosphere. This review paper is an attempt to understand, analyse and suggest trends and developments taking place in the domain of carbon footprint reduction found in supply chain, what is the benefit of accounting for carbon footprint, what all steps can be taken to reduce carbon footprint and still make profit.

Keywords: Carbon footprint, Muda, Supply chain

I. INTRODUCTION

We are constantly confronted with environmental changes across the world ranging from extreme weather to a scarcity of water for nearly 2 billion people, nearly 40% of the world's population. The increasing concern on climate change issues, the emission of Greenhouse gas (GHG) all over the world and how to account, manage and reduce them is a hot topic. "Carbon footprint" is a term used to describe the amount of GHG emissions caused by a particular activity or entity. Understanding these emissions, and where they come from, is necessary in order to reduce them. In the past, companies wanting to measure their carbon footprints have focused on their own emissions, but now they are increasingly concerned with emissions across their entire supply chain.

Measuring the carbon footprint of goods/services across their full life cycle is a powerful way for companies to collect the information they need to reduce GHG emissions, identify cost savings opportunities, incorporate emissions impact into decision making on suppliers/materials/product design/manufacturing processes, demonstrate environmental/corporate responsibility leadership, meet customer demands for information on product carbon footprints and differentiate/meet demands from "green".

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The upcoming International Standard ISO 14067, Carbon footprint of products – Requirements and guidelines for quantification and communication, is being developed to increase transparency in quantifying and reporting CO2 emissions over the entire lifecycle of products and services – from production to recycling or waste disposal. The document is currently at the stage of Draft International Standard (DIS) and expected to be finalized for publication in March 2014, [1].

II. SUPPLY CHAIN MANAGEMENT

Supply chain management is the management of activities involved in purchasing materials, transforming them into intermediate goods and final products and delivering a product or service. The sequence begins with the basic suppliers of raw materials and extends all the way to the final customers. The facilities involved in an assembly-type supply chain such as automotive component manufacturers include warehouses, factories, processing centres, distribution centres, retail outlets and offices. Activities include forecasting, planning, purchasing, inventory management, information management, quality assurance, scheduling production, distribution, delivery, disposal and customer services. It is clear that supply chain management includes all those activities involved in the flow of materials through the supply chain.

2.1 Wastes in supply chain

Muda is a Japanese word meaning "futility; uselessness; idleness; superfluity; waste; wastage; wastefulness", and is a key concept in the Toyota Production System(TPS) as one of the three types of waste (muda, mura, muri).Waste reduction is an effective way to increase profitability. Toyota merely picked up these three words beginning with the prefix mu-, which in Japan are widely recognized as a reference to a product improvement program or campaign. A process adds value by producing goods or providing a service that a customer will pay for. A process consumes resources and waste occurs when more resources are consumed than are necessary to produce the goods or provide the service that the customer actually wants. The attitudes and tools of the TPS heighten awareness and give whole new perspectives on identifying waste and therefore the unexploited opportunities associated with reducing waste. [5]

Muda has been given much greater attention as waste than the other two which means that whilst many Lean practitioners have learned to see muda they fail to see in the same prominence the wastes of mura (unevenness) and muri (overburden). Thus whilst they are focused on getting their process under control they do not give enough time to process [4]

Traditionally following muda have been identified in supply chain

Motion, the poor design can severely affect productivity as workers and machines perform unnecessary motion through driving and walking.

Delay, the increase in lead time as operations wait for material or as a result of line stoppages. Delays can also have a negative affect on customer service in the organization.

Conveyance, this is caused by poor layout and traditional batch production. Moving processes closer together can reduce this type of waste.

Correction, having to fix defective products and the cost associated with this type of waste.

Over processing, the companies may sometimes lose touch with what customers require. Incremental performance improvements might not always fit in with customer requirements and add little or no value.

Inventory, there is both good and bad inventory. Unnecessary inventory not linked to demand can be classified as bad inventory.

Overproduction, that is producing things that you don’t sell. Overproduction is also the root cause of other types of inventory including waiting, motion and inventory.

Knowledge disconnection, the poor flow of knowledge, ideas and creativity in the organization. Poor collaboration among supply chain partners can also lead to knowledge disconnect in the organization.

III. CARBON FOOTPRINT

A carbon footprint has historically been defined as the total set of greenhouse gas (GHG) emissions caused by an organization, event, product or person. The concept name of the carbon footprint originates from ecological footprint, discussion, which was developed by Rees and Wackernagel in the 1990s which estimates the number of "earths" that would theoretically be required if everyone on the planet consumed resources at the same level as the person calculating their ecological footprint. However, carbon footprints are much specific than ecological footprints since they measure direct emissions of gasses that cause climate change into the atmosphere.[5]

However, calculating the total carbon footprint is impossible due to the large amount of data required, the relatively recent attention brought to this issue within the last century, and the fact that carbon dioxide can be produced by natural occurrences. It is for this reason that Wright, Kemp, and Williams, writing in the journal Carbon Management, have suggested a more practicable definition:

"A measure of the total amount of carbon dioxide (CO_2) and methane (CH_4) emissions of a defined population, system or activity, considering all relevant sources, sinks and storage within the spatial and temporal boundary of the population, system or activity of interest. Calculated as carbon dioxide equivalent (CO_2e) using the relevant 100-year global warming potential (GWP100)."

A carbon footprint considers all six of the Kyoto Protocol greenhouse gases: Carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulphur hexafluoride (SF_6). [6]

A carbon footprint is measured in tonnes of carbon dioxide equivalent (tCO2e). The carbon dioxide equivalent (CO2e) allows the different greenhouse gases to be compared on a like-for-like basis relative to one unit of CO2. CO2e is calculated by multiplying the emissions of each of the six greenhouse gases by its 100 year global warming potential (GWP). [1]

3.1 Types of carbon footprinting

The main types of carbon footprint for organisations are:

a. Organisational carbon footprint-Emissions from all the activities across an organisation, including buildings' energy use, industrial processes and company vehicles.
b. Value chain carbon footprint -Includes emissions which are outside an organisation's own operations (also known as Scope 3 emissions). This represents emissions from both suppliers and consumers, including all use and end of life emissions.
c. Product carbon footprint- Emissions over the whole life of a product or service, from the extraction of raw materials and manufacturing right through to its use and final reuse, recycling or disposal.

3.2 Measuring Carbon Footprints

An individual's, nation's, or organisation's carbon footprint can be measured by undertaking a GHG emissions assessment or other calculative activities denoted as carbon accounting. Once the size of a carbon footprint is known, a strategy can be devised to reduce it, e.g. by technological developments, better process and product management, changed Green Public or Private Procurement (GPP), carbon capture, consumption strategies, and others. Several free online carbon footprint calculators exist, with at least one supported by publicly available peer-reviewed data and calculations from the University of California, Berkeley's CoolClimate Network research consortium. [5]

The mitigation of carbon footprints through the development of alternative projects, such as solar or wind energy or reforestation, represents one way of reducing a carbon footprint and is often known as Carbon offsetting.

The main influences on carbon footprints include population, economic output, and energy and carbon intensity of the economy. These factors are the main targets of individuals and businesses in order to decrease carbon footprints. Scholars suggest the most effective way to decrease a carbon footprint is to either decrease the amount of energy needed for production or to decrease the dependence on carbon emitting fuels.

In an effort to address the growing evidence of climate change, many nations are passing laws and regulations aimed specifically at reducing carbon emissions and greenhouse gas from the atmosphere.

The focus on sustainability has resulted in a growing need for integrating environmentally sound choices or “Green initiatives” into research and practices at individual and organisational level in diverse sectors. [5]

IV. CARBON MANAGEMENT MODELS

4.1 Carbon as a Muda of Supply chain

“CO2 emissions should be seen as the new muda of the supply chain”, says Mondher Ben-Hamida, associate partner at IBM Corp.

Various studies show that Supply Chain related activities (i.e. industrial and transportation) account for close to half of the world’s energy consumption. Modelling and optimizing GHG emissions in manufacturing and logistics operations is therefore of paramount importance if the global community is to seriously tackle the environmental issues facing the planet. However, and despite the rather urgent nature of this global challenge, the momentum behind the green movement lost some strength because of the economic slowdown. Most of the business world continues to perceive the sustainability dimension as a rather costly undertaking with no clear ROI and hence to be tackled only when times are good. Our talk will aim to prove that embracing greener practices is good business and making the shift starts with a surprisingly simple move: approach GHG emissions as just another operational decision variable.[2]. Considering CO2 as the new Muda (the Japanese term for ‘waste’ in lean practices) and optimizing its amount within the extended supply chain in line with current practices that aim to reduce cost and inventory is key to taking sustainability mainstream within the operations management community.

Figure1. Carbon as a Muda of Supply chain

Source: Thoughts on Carbon as the New Muda, E2open, Inc

At least half the global carbon emission can be attributed to supply chain activities. Accurate measurement of the carbon associated with these activities and identification of cost-effective ways to reduce it are challenging. IBM Research developed a framework for modelling carbon in supply chains and conducted three pilot implementations. The software solutions created in these implementations are designed to calculate carbon emissions and analyse the trade-offs between carbon and other metrics in supply chains such as warehousing and transportation costs, inventory, and service levels. The solutions also provide extensive scenario analysis capabilities to evaluate the impacts of various supply chain actions on operational, financial, and environmental metrics.

4.2 The 21st Century supply chain model

According to Tata Consultancy Services team, the changing expectations, pressures and realities of the business environment requires a new supply chain, capable of delivering growth while minimising carbon emissions. [3]. While building on the strengths of the existing model in terms of its capability to handle high volumes with low inventory transaction costs, the distinguishing feature of the 21st century supply chain is its shape – a "closed loop" rather than a straight line. Envisioning all actors as part of a cycle will overcome some of the current model's limitations and enable the systematic pursuit of cost and environmental efficiencies throughout the product cycle; more collaborative and flexible information exchange among partners; and quicker response times to changing market dynamics. Developing closed-loop supply chains will demand innovative collaboration among supply chain constituents, taking into account the forward product and reverse resource flows. The key actors in the collaborative 21st century supply chain model are:

1. Suppliers
2. Manufacturers
3. Logistics service providers
4. Distribution partners
5. Consumers
6. Repair, remanufacturing and recycling partners

Dealing with 21st century business realities means that these actors need to start working with a closed loop model. Diverting the physical flow from the landfill back into the product chain requires collaboration from all supply chain partners, drawing on smart and integrated information exchange between direct and indirect partners across the supply chain. [3]. The closed loop system will be supported by changing the way information is collected, handled, processed and shared. Most importantly the new supply chain model will enable:

a. Going from bilateral to multilateral connectivity. Currently, connectivity is mostly bilateral, restricted between a company and its direct suppliers and customers. To improve\efficiencies and respond to simultaneous changes in many areas of the supply chain, communication needs to become two-way and connectivity to become multilateral, encompassing all the key players in the supply chain (both direct and non-direct actors).
b. Integrating new types of information on, for example, sustainability performance or real-time indicators (eg, logistic fill rate). This will optimise the entire supply chain by generating intelligence about, for example, total supply chain cost, low-carbon logistics performance and product waste reductions.
c. New capabilities to arise as a result of enhanced connectivity and integration of sustainability and actor information. As this information can be made accessible to a larger set of stakeholders, real-time decision making, reverse chain integration and design for product sustainability can become reality. One such capability could be migrating from a product- to service-based model. Enabling a service-based business model would require significant restructuring in the supply chain.

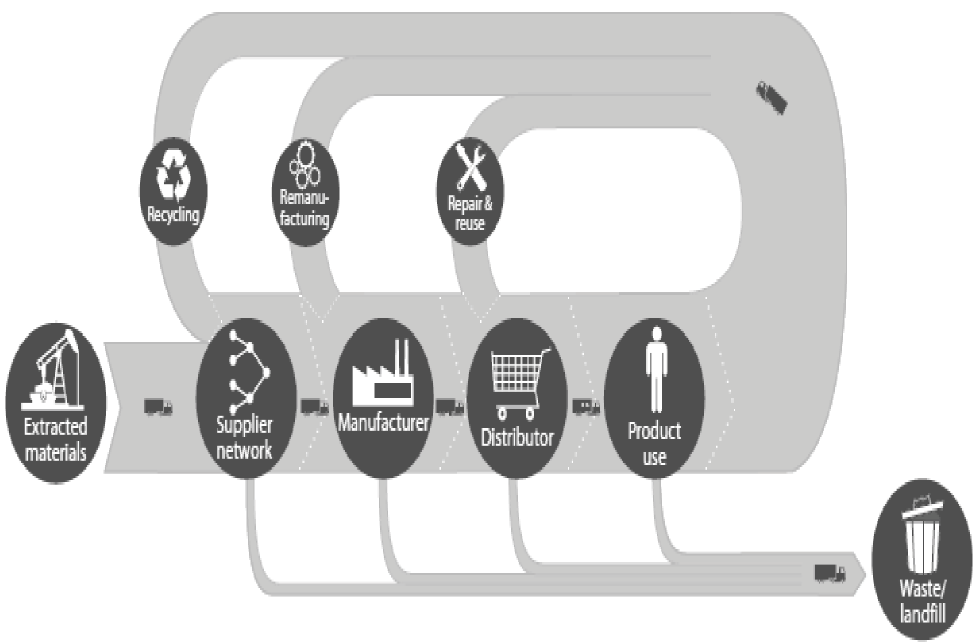

Figure 2. The 21st century supply chain model

Source: The 21st century supply chain model, Tata Consultancy Services

The 21st century supply chain model needs to be supported by an "information and collaboration hub" – a smart, integrated information exchange to deliver transparency and visibility across the supply chain. [3]. All supply chain actors would be able to access the hub in this new supply chain model the information and collaboration hub enables connectivity among the various actors in the supply chain. The principal company or an external third party could serve as the natural focal point or 'hub', ensuring all supply chain actors is able to provide and extract relevant information. Multilateral connectivity will enable visibility and access to data across all the players in the supply chain, underpinning new collaborations. Information systems, – Enterprise Resource Planning (ERP), Transport Management System (TMS), Product Life-Cycle Management (PLM), Customer Relationship Management (CRM), Supplier Relationship Management (SRM) and others – could process information captured in the supply chain. [3]. A smarter hub that could enable new capabilities through tools such as real-time monitoring and decision making, capability-to-promise, collaborative designs and development, reverse chain planning and online exchanges (logistics, energy, materials, waste management, etc).

V. CONCLUSION

Companies can use a supply chain approach to search for new ways of reducing carbon emissions, just as they have been using supply chain analysis to deliver financial benefits. Measuring the carbon footprint of a value chain allows companies to make enhanced, more informed decisions about how to run their own operations. Particular benefits are; improved productivity, increased efficiency, reduced waste, lower capital requirements, and enhanced product development.

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