ResponsibleSCOR

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Abstract

The paper suggests an extension of the SCOR model to include environmental sustainability. It argues that the current GreenSCOR framework, which is part of the 11th edition of the SCOR model leaves out many elements of environmental impacts. It suggests several extensions upstream and downstream in the supply chain, including even the use phase of products. It also suggests and gives example of "best practices" in several of the area mentioned.

The global economy faces the significant challenge of delivering a rising standard of living to a growing human population without irreversibly damaging the natural environment upon which all life depends. Much has been written about this challenge of environmental sustainability for corporations and society, be it the use of non-renewable energy resources, water scarcity due to displacement and contamination, climate change risks, habitat degradation, species extinction, and the impact of waste disposal. Massive media exposure, consumer educational initiatives, regulatory activities by governments the world over, and environmental activist NGO (Non-Governmental Organization) attacks on offending corporations have brought the issue front and center to corporate executives. Some 81% of nearly one thousand supply chain executives surveyed in 2014 cited brand image concerns as a motivation or investing in sustainability (O'Marah, 2014).

At the same time that supply chains enable the availability of goods and services that satisfy needs and wants, their operations – from extraction to refining, sub-assembly, manufacturing, distribution, and retail operations – are heavily consuming natural resources and emitting carbon dioxide, air pollutants, waste water and solid waste. The environmental challenge, then, is how to continue increasing the world's standard of living while also decreasing the environmental impact of supply chain operations. For example, Unilever, the €50 billion multinational consumer goods giant, has a vision to: "to double the size of the business, whilst reducing our environmental footprint" (Unilever, 2013). Similarly, Royal Dutch Shell PLC Chairman Jorma Ollila called for society to "find a 'middle way' that 'doesn't threaten economic growth'" (Scheck, 2015). The challenge is immense given the continuing growth of the world population with births outpacing death by well more than 2:1.

1. Modeling and Managing Supply Chains for Sustainability

Sustainability can be viewed as a strategic goal – like high reliability or low cost – that an organization's managers seek to achieve or optimize. To help firms measure, diagnose, and benchmark internal business processes across different products, geographies, and networks, the Supply Chain Council (SCC) developed the Supply Chain Operations Reference Model (SCOR®).[1] The SCOR model, on its 11th version in 2013, comprises a hierarchical model of supply chain processes, a set of business performance attributes, a long list of business practices, a long list of skills, and a map of the interrelationships between processes, performance, practices, and skills.

[1] SCOR is a trademark of the Supply Chain Council

1.1. SCOR Process Model

SCOR defines six categories of supply chain processes: plan, source, make deliver, return, and enable (Supply Chain Council, 2012). "Plan" covers all the managerial tasks of balancing supply and demand to create a course of action that will meet customer requirements within the constraints of manufacturing capabilities and available supplies of parts and material. "Source" refers to the processes for procuring materials, parts, and services from suppliers in the upstream supply chain. "Make" processes include those for converting sourced materials into finished goods. "Deliver" covers the downstream, customer-facing supply chain activities of warehousing, distribution, and transportation that fulfill customer orders. "Return" includes processes for handling defective products and repairs, as well as re-manufacturing. "Enable" is the process of managing the information, relationships, business rules, compliance, performance measurement, and other elements needed for governance and execution of supply chain activities.

These high-level processes are, of course, replicated within each of the companies along the supply chain, leading to the scheme depicted in Figure 1:

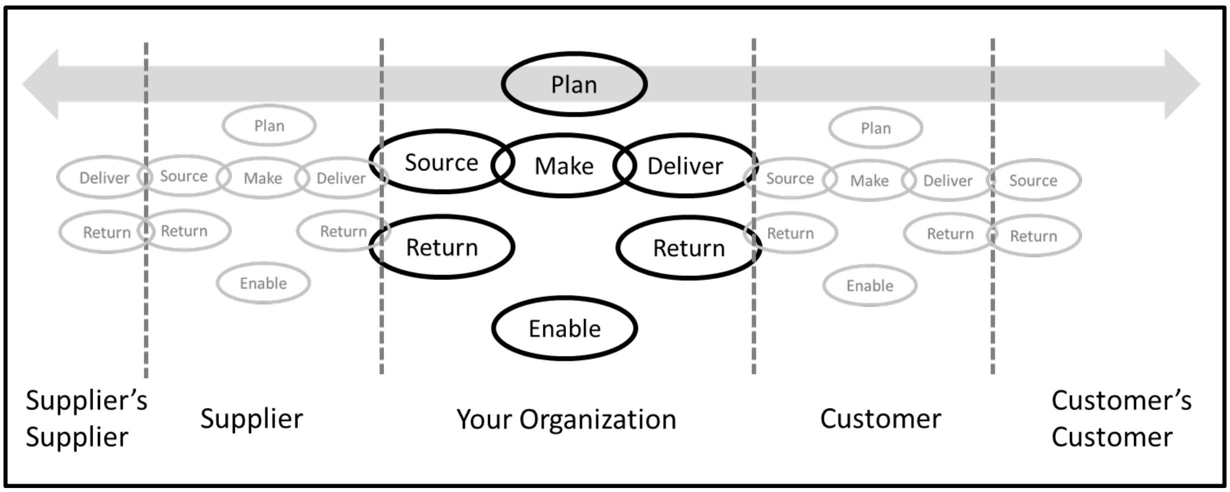

Figure 1 SCOR 11 Level 1 Processes

The SCOR framework is much more detailed and deep than Figure 1 implies. The processes depicted here are only the high level ("level 1") definition of the scope and content of a supply chain. Level 2 includes process categories defining the operations strategy, while level 3 defines the configuration of individual processes. Note that in this view the "Plan" process encompasses the entire supply chain, while the "Source" and "Return" (to suppliers) processes interface with suppliers and the "Deliver" and "Return" (from customers) processes interface with customers. "Enable" interfaces with both suppliers and customers. This figure can be summarized with a focus on the company as shown in Figure 2:

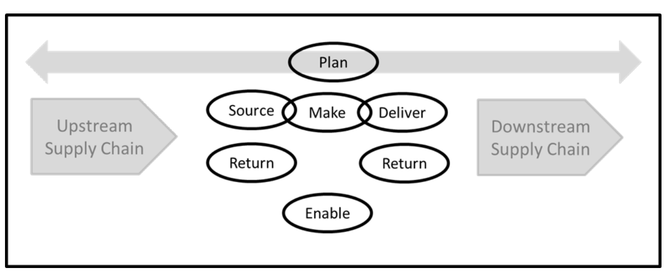

Figure 2 Simplified SCOR Process Map

1.2. SCOR Performance Attributes

SCOR defines processes at a very generic level that is independent of the strategic goals, performance attributes, or metrics used by managers to optimize the metrics they are responsible for. The current version of SCOR identifies five categories of high-level performance attributes: reliability, responsiveness, agility, costs, and asset efficiency. Each performance attribute comes with one or more level-1 strategic metrics which, in turn, break down into lower-level metrics on the lower-level processes. For example, the level-1 strategic metric for the cost attribute is "total cost to serve," which breaks down into metrics such as planning cost, sourcing cost, material landed cost, production cost, order management cost, fulfillment cost, and returns cost, each of which is tied to its respective processes. Similarly, each process and sub-process in the SCOR model affects one or more metrics including cost, cycle times, asset utilization, and process reliability.

1.3. GreenSCOR Metric

Sustainability requires new metrics. To be both profitable and sustainable, supply chains have to balance corporate growth -- which offers associated improvements in standards of living for the growing world population -- and environmental impacts, which harm the environment and people in multiple ways. To this end, many brand-name companies have taken steps to measure and report improvements on the environmental sustainability of their operations as part of, or in addition to, measuring and reporting financial metrics. In support of this goal, the latest revision of the SCOR model includes "GreenSCOR" under its "Special Applications" section. It comprises a set of environmental metrics that can be measured at sub-process levels and aggregated into the Plan-Source-Make-Deliver-Return framework.

GreenSCOR is focused on measuring the carbon footprint, emissions, and recycling associated with each of its five level-1 processes.[2] The GreenSCOR definition is:

Total Supply Chain Environmental Footprint =
Total Supply Chain Air Emissions +
Total Supply Chain Liquid Emissions +
Total Supply Chain Solid Waste Emissions * (1 - % waste recycled)

Naturally, these emissions can be weighed by the impact on the environment. For example, some emissions into the oceans impact coral reefs and sea life while others are more innocuous.

Unlike the detailed measurements associated with its traditional supply chain processes, the metric suggested by GreenSCOR does not point directly to processes and actions that can improve the environmental performance of supply chains.

2. Sustainability's Scope beyond SCOR 11

While useful, the GreenSCOR approach seems to regard environmental sustainability as an appendage to the main supply chain processes. It is not even integrated into the SCOR framework of top-level attributes. If sustainability is essential to the survival of the company and planet, then it must be a goal as important as cost, reliability, asset utilization, or other strategic

[2] The "Enable" process is excluded from the GreenSCOR in Revision 11.

performance attributes in the SCOR model. The underlying philosophy of environmental sustainability implies an expansion of the responsibility of companies and an expansion of the SCOR model. The resulting extended model can called ResponsibleSCOR, to reflect the greater level of supply chain responsibility required to achieve sustainability. ResponsibleSCOR includes three extensions to the SCOR model: an extension of the set of performance attributes to include sustainability; an expansion of the SCOR system to include players that affect sustainability; and a number of emerging business practices to both measure and improve sustainability of supply chains.

2.1. Beyond GreenSCOR: Impacts of Consumption

GreenSCOR only measures half the environmental impact, in that it only measures the environmentally impactful *outputs* of supply chain processes. Yet, in 2010, Greenpeace waged a multi-pronged campaign against Nestle, Unilever, and other brand owners not over emissions but over destruction of tropical rainforest for palm oil production.

GreenSCOR ignores impacts from the consumption of scarce and non-renewable resources. For example, many areas suffer from water scarcity or water sustainability problems, such as declining aquifers, dwindling river flows, and drying lakes. GreenSCOR also ignores environmental impacts of unsustainable levels of harvesting of wood, seafood, and other natural ingredients. Finally, most products also include nonrenewable metals or minerals extracted from the ground at significant cost to the environment around the mine.

The common thread in all these other types of impacts is that they represent *inputs* to the supply chain of scarce or non-renewable natural resources. Thus, a more complete SCOR-related sustainability metric must be extended to encompass both emissions and consumption. One potential definition of the combined footprint of emissions and consumption could be:

Total Supply Chain Environmental Footprint =
Total Emissions Footprint (e.g., GreenSCOR)+
Total Consumption Environmental Footprint

Where:
Total Consumption Environmental Footprint =
Supply Chain Mineral Consumption +
Total Supply Chain Natural Products Consumption +
Total Supply Chain Water Consumption * (% in potable water stressed areas) +
Total Supply Chain Land Footprint * (% in environmentally-sensitive areas[3])

Naturally, each element in these expressions (and the elements in the GreenSCOR) have to be weighed in term of their environmental impact.

[3] Environmentally-sensitive areas include tropical rainforests, old-growth temperate zone forests, wetlands, and the habitats of endangered species.

2.2. Beyond Retail: the Consumer

The SCOR model, with its focus on managing organizations, explicitly stops at the retailer. Consumers are out-of-scope for SCOR except as an outside force that generates demand, shops in stores, and returns defective products, which then trigger activities by retailers, manufacturers, logistics service providers and other participants in the supply chain proper. Yet the environmental impacts of supply chains extend beyond the retailer's cash register in ways that may be controlled and certainly can be influenced by the company. The environmental impact of a carmaker's vehicle depends on fuel consumed by the vehicle and the consumer's driving habits. The sustainability of a laundry detergent depends on the water temperature set by the consumer and the carbon emissions created to heat water. To the extent that a product's use by the consumer is associated with environmental impacts, these impacts are part of the product's total environmental footprint.

With this view in mind, the scope of the SCOR model can be expanded to encompass consumers, as shown in Figure 3. Although SCOR is not about modeling consumer processes, environmental best practices do depend on encompassing consumer activities into the supply chain. Note that while these downstream echelons are the responsibility of the company in the sense that a product's environment impact reflects back on the sustainability of the company, by and large, the company can only *influence* these environmental outcomes rather than *control* them. In other words, companies cannot force consumer to do certain things while using their product, they can only provide information, engage in marketing, and create a social environment were certain practices are considered irresponsible or "bad". Note that in Figure 3 the "Enable" process stretches along the entire supply chain in order to indicate this responsibility.

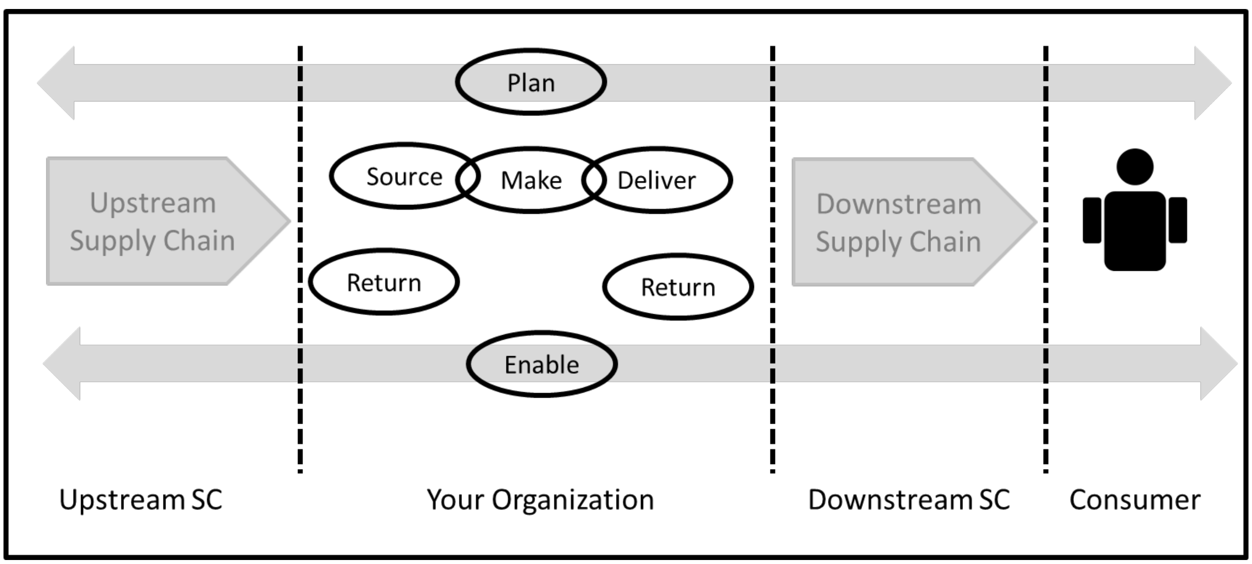

Figure 3 ResponsibleSCOR High Level Processes

2.3. Beyond the Consumer: Extended Producer Responsibility

In the absence of environmental initiatives such as recycling, the entire production output of most companies eventually becomes solid waste, liquid contaminants, or atmospheric emissions during the use and discarding of the product. The environmental impact of a product such as an electronic device or battery depends on whether the product leaches toxic metals after it goes in the trash. This fact pushes the SCOR model even further beyond the consumer to make the producer also responsible for the post-consumer chain of activities that handle end-of-life products.

The concept of extended producer responsibility (EPR) originated in 1990 with Swedish professor Thomas Lindhqvist (1990) in a report to the Swedish Ministry of Environment. EPR shifts responsibility for long-term waste-management from local governments and municipal waste handlers back to the companies that manufactured the original product (Morawski, 2009). In 2007, the European Union introduced the Waste Electrical and Electronic Equipment (WEEE) Directive, a performance based waste treatment initiative. This regulation requires original equipment manufacturers of electronic products to be responsible for, and bear the costs of, collecting and disposing of them at the end of their life. The EU regulation "puts the onus on distributors to accept WEEE from consumers" (European Commission, 2007). Other jurisdictions have adopted similar EPR regulations for various product categories. In 2013, EPR regulations were in force in California for carpet, paint, and mercury thermometers. Similar regulations were in force in Canada, Japan, and several other countries, requiring EPR for items such as packaging, batteries, and hazardous substances (CalRecycle, 2013).

3. Emerging Practices for Supply Chain Sustainability

The SCOR model catalogs some 174 practices, cross-referenced by the processes and performance metrics to which each practice might contribute. Sustainability adds a number of new practices by which companies can reduce the total impact of a product or a process. Many of these impact-reducing practices fall under the oft-heard environmental slogan of "Reduce, Reuse, Recycle." Other practices concern supply chain management on both the upstream and downstream directions, including influencing the practices of suppliers – over which the company has some power; customers (such as retailers) with whom companies can (and many do) cooperate to find sustainable solutions, and consumers, over whom the company has limited influence.

3.1. Sustainability Life Cycle Analysis

The first emerging practice needed to manage supply chains for sustainability provides a structured approach to measuring the complete environmental footprint of the supply chain of a product. The SCOR "Plan" process already spans the entire supply chain and includes sub-processes to "Identify, Assess and Aggregate" the resources consumed by the supply chain, products, production, and the various high-level processes of the company. These are managed in accordance with the strategic attributes and metrics chosen by the company. In the context of sustainability, the best practice for identifying, assessing, and aggregating the impact is Life Cycle Assessment (LCA), which is a formal methodology for analyzing all of the various inputs (consumption) and outputs (emissions) associated with a product as value is added throughout the supply chain.

LCA is different from product lifecycle management (PLM) in several regards. LCA concerns the material and environmental inputs and outputs of a single unit or specific quantity of the product. The scope of an LCA spans raw materials, parts, a unit of finished good, consumer use, and on to the disposal of that one unit. In contrast, PLM concerns the overall timing and management of a product model or SKU (stock keeping unit). The scope of PLM spans R&D conception, engineering design, factory manufacturing, servicing, and eventual obsolescence of that type of product.

Measuring the environmental impact of products and processes involves understanding the entire supply chain, which can be complex even for simple products. For example, one would have been hard pressed to find a "simpler" product than a banana. The "product" includes a single part and comes with its own packaging. Yet a detailed LCA of bananas performed by the MIT Center for Transportation and Logistics in conjunction with Chiquita Brands International Inc. and Shaw's, the grocery store chain, demonstrated how complex can even such a "simple" LCA can be (Craig, 2012). Chiquita manages hundreds of farms in Latin America and employs six ocean transportation services that unload bananas at five U.S. ports and eight European ports. The company also operates nine distribution centers in the U.S. and 11 in Europe, where it supplies bananas to hundreds of retailers that distribute them to thousands of retail outlets.

The exact footprint depends on the exact path of each box of bananas and the transportation modes used. Furthermore, the banana flow is part of a much larger global commercial and industrial network providing fertilizers, water, energy, vehicles, packaging, and myriad of other ingredients needed to plant, grow, harvest, and ship the bananas. The fruit's carbon impact begins before its growth on a farm: at chemical factories, forests, paper mills, coal mines, and power plants.

In order to ensure tractability, the MIT project limited the scope of direct data collection to the primary actors only. Even then, the researchers identified 56 primary materials and processes across 16 major supply chain stages (see Figure 4) required to get a banana from the farm to a U.S. consumer. Using specialized LCA software[4] designed to measure environmental impacts, the original 56 materials and processes expanded to become more than 1,500 supply chain activities spanning the globe that are ultimately required to produce and deliver bananas. The contribution of each of these supply chain activities and materials had to be traced and accounted for to arrive at average carbon footprint estimates. And this was just the carbon footprint. It did not include impacts such as pesticide runoff at farms, airborne particulates spewed by banana hauling trucks, solid waste from the discarded banana boxes and banana peels, or the land use of banana plantations in tropical regions.

[4] Pre. "SimaPro LCA Software." http://www.pre-sustainability.com/simapro-lca-software.

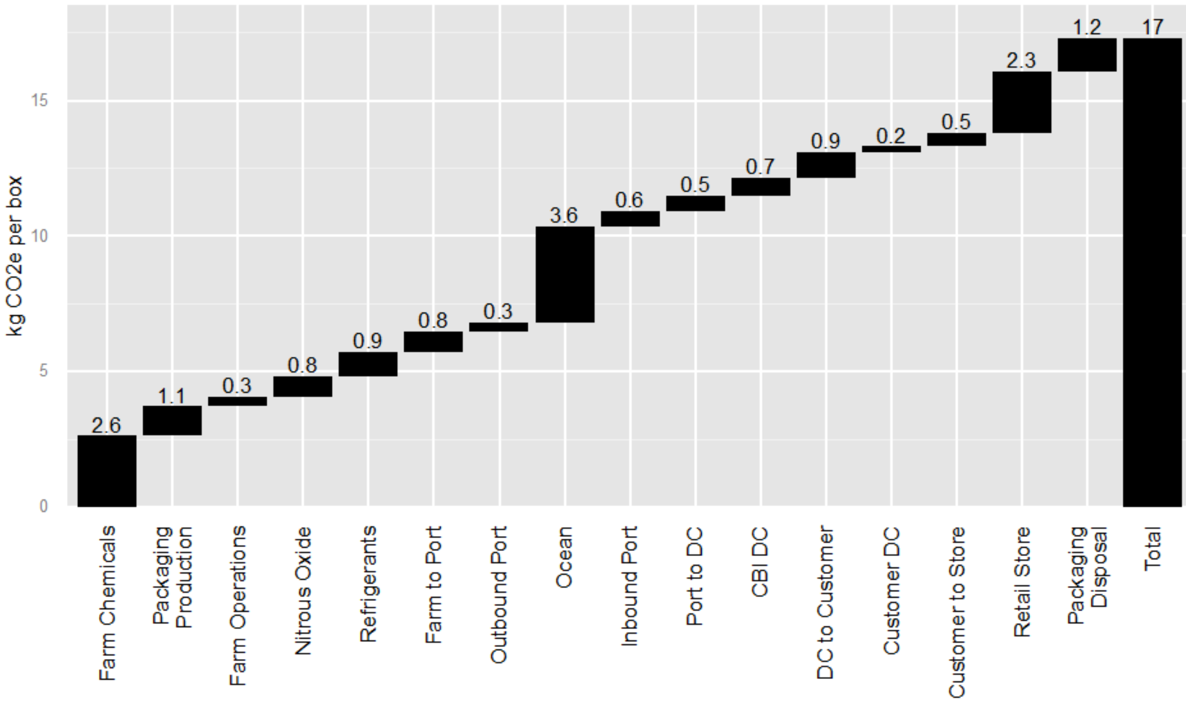

Figure 4 Results of Banana LCA

Although the LCA is primarily a part of the "Enable" sub-processes that manage performance, data, and information, the results of an LCA will affect decisions made in the "Plan," "Source," "Make," "Deliver" and other processes. Consider a seemingly simple sourcing choice for a UK company of whether to buy local UK-made recycled paper or imported Swedish-made virgin paper. On one hand, local recycled paper clearly saves on transportation and trees. Yet the carbon footprint of virgin Swedish paper is actually lower than that of UK recycled paper, due to the UK's reliance on coal-fired power plants vs. Sweden's use of nuclear and hydroelectric energy to manufacture paper (Grenon, 2007). Similarly, oranges grown in Brazil might have a higher water footprint than oranges grown in Spain, but Brazilian oranges may have a lower environmental impact on water stress owing to the rainy climate and abundance of water in the citrus regions of Brazil (Alter, 2009). Thus, only a comprehensive system-wide LCA analysis can point to the right sustainability choices.

Harry Teasley, the packaging manager for Coca-Cola, is generally credited with performing the first LCA in 1969 when he compared the environmental impact of glass and plastic bottles — a study that ultimately upset conventional wisdom. By examining the full life cycle of the bottle, the analysis concluded that plastic would actually be better (even though glass is a more "natural" material) because plastic bottles are lighter and therefore require less energy to transport. Coca-Cola could also produce plastic bottles in-house, reducing transportation distances; plastic was also easier to recycle at the time (Hung and Franklin, 1996). Although the study was never formally published, it was said that Coca-Cola felt more "comfortable" in its choice to switch to plastic knowing these results.

The importance of including LCA is that it can point out certain "hot spots" where the environmental impact is particularly intense. Such hot spots can then be the focus of planning processes aimed at reducing the environmental impacts. A complete LCA process is difficult and time consuming. However, there are simplified practices of "fast foot-printing" (Meinrenken et al., 2012) that are usually sufficient for identifying hot spots.

3.2. Low-Impact Substitutes

From a sustainability standpoint, *what* gets emitted can be more important than *how much* gets emitted. Consider, for example, chlorine and compounds of chlorine used in the bleaching of wood pulp to make paper. Paper factories using elemental chlorine produce significant quantities of dioxins (Health Canada and Environment Canada, 1991), which are some of the most toxic human-released pollutants in existence. Since 1990, paper makers substantially reduced the use of elemental chlorine in the delignification process through a (mostly) Chlorine Free bleaching processes. Substitution of a hazardous chemical (chlorine) for less hazardous ones (ozone and hydrogen peroxide) reduces the toxicity of emissions.

Other examples of low-impact substitutes include biofuels and bioplastics. Instead of using fossil fuels as a chemical feedstock for transportation fuels, industrial heating, and chemical synthesis, the bio-based approach starts with starch, seed oil, or cellulose from grains, seeds, or agricultural waste. A series of enzymatic, biological, or chemical processing steps converts the starch, oil, or cellulose into fuels and polymers that are largely identical to their fossil fuel cousin but which may have much lower environmental impacts.[5] All downstream products and supply chain processes inherit the low impact of these biofuels and bioplastics.

Changing the chemistry of a key manufacturing technology affects the "source" and "make" processes of SCOR. But if the substitution is deep in the supply chain – at the level of feedstock chemicals – then it is only the "source" that changes to ensure that the company is buying the components that use the "green" version of some raw material. Ensuring that suppliers deep in the supply chain, over whom companies may have limited control, use sustainable materials and processes requires practices that will be discussed in the next section.

3.3. "Assetize" Consumables

In addition to the flow of products in a supply chain comes a flow of other consumable items, such as packaging, that accompany the product. In many supply chains, packaging and other similar items are discarded, creating impact in both the production and the discarding of the item. For example, Subaru's American factory in Indiana[6] was discarding 33,000 pounds a year of temporary brass lugnuts used by Subaru's wheel supplier to secure the wheels during transit.

Subaru worked directly with its wheel supplier to return the lug nuts and reuse them until they are no longer serviceable, at which point they are recycled for brass material (Kahn, 2011). Subaru also returns Styrofoam forms used to cushion delicate components on their trip from Japan so that they can be reused in future shipments. After five reuse cycles, the Styrofoam ends up in Japan, where 85 percent of it is recycled (Subaru of Indiana, 2012). Suppliers were also

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[5] Biofuels and bioplastics may have more impact than first appears. Agricultural and transportation impacts may offset the carbon-negative qualities of these products. The products also have land use issues and affect global food prices.

[6] This factory makes both Subaru and Toyota vehicles.

asked to ship certain parts in reusable, blue plastic bins instead of cardboard boxes. By converting the consumable into an asset, the cycle times become part of the sustainability metric – the faster the return of the packaging, the higher the utilization of that asset, and the lower the total number of the assetized consumables in the system.

If the consumable crosses company boundaries, such as packaging, then assetizing that consumable employs the SCOR "Return" process to send the item back for reuse. But this use of the return process is different from the existing SCOR model for the "Return" process, which recognizes only three distinct reasons for product returns: defects, excess inventory, and what SCOR calls MRO (maintenance, repair, and overhaul). The existing return process generally occurs infrequently for a small portion of the production volume. In contrast, the returns for an assetized consumable are routine and may occur with 100% of the production volume on a relatively short cycle time.

Subaru's work to convert disposable items into reusable assets was part of a broad program to reduce solid waste. "People still think that it costs too much money to be environmentally friendly," said Denise Coogan, Subaru's manager of safety and environmental compliance. "That's an antiquated idea. Waste is money: wasted time, wasted material. The first years cost us financially, but after you get over that hump, you see the [monetary gains] take off exponentially" (Kahn, 2011).

Assetizing a consumable changes how the item is managed under the various SCOR processes and SCOR performance attributes. A consumable is generally something to source at minimum cost – a lugnut that gets used only once can be the cheapest possible lugnut. In contrast, an asset is an item that is selected for longevity of service and then managed for asset utilization. In the short-term, the cost (and production-related environmental impact) of each lugnut might climb as the company buys a pool of high-quality lugnuts that are reused. Yet the greater the longevity and utilization, the lower the cost and environmental impact per use of that lugnut asset.

3.4. Cogeneration: Converting Byproducts into Value

Many industrial processes produce heat while others use heat. For example, making electricity produces waste heat, which then requires cooling systems (which consume water) to remove. Cogeneration, also called combined heat and power (CHP) is the intentional co-location of power generation and heat-dependent manufacturing systems. For example, Unilever spent around €28 million on its cogeneration program in Europe. With cogeneration, Unilever captures more of the total energy latent in the fuel than a traditional power plant would and avoids the need for separate boilers. The program made both sustainability and profitability sense – it saves 60,000 tons of CO_2 and about €10 million a year (Dunnage, 2012).

The concept behind cogeneration can extend to other "make" processes that produce significant quantities of byproducts, such as those in chemicals and agricultural products industries. The key is scale and integration. In a smaller, more specialized chemical plant, the byproducts of the "make" process appear in volumes too low to be economically viable for sale or further refinement – they are typically burned for fuel. But by integrating multiple large production facilities that can feed off each other's byproducts, the volume of the byproducts increases and the cost of further processing those byproducts into valuable goods drops.

BASF, the large German chemical producer, uses this practice of integrated production, which it calls “verbund,” the German word meaning “combined,” “linked,” or “grouped.” The largest of BASF’s six verbund sites is Ludwigshafen, which integrates 160 production facilities interconnected by 2,750 km of pipelines on a 10 square km campus. The company claims that “At our Verbund sites, production plants, energy and waste flows, logistics, and site infrastructure are all integrated” (BASF, 2014).

Cogeneration and verbund call for a more complex vision of the supply chain than the linear stages shown in the typical SCOR diagram. A supply chain becomes a supply mesh in which each “make” step might consume multiple raw materials and produce multiple outputs. This mesh can even contain loops, such as if a byproduct chemical from one production facility provides a key ingredient to a second facility while the second facility produces byproduct heat used to power the first facility. With verbund, every production unit is potentially both a supplier and a customer of every other production unit. This holistic vision is also found in the concept of the circular economy – a sustainability concept borrowed from ecological sciences in which materials continually cycle in the environment (Ellen MacArthur Foundation, 2012).

3.5. Recycle

Recycling converts scrap, defective, or end-of-life products back into their component materials, which are then put back in the supply chain at an earlier stage of production. Recycling improves performance on SCOR sustainability metrics by both reducing emissions – diverting the waste from landfills – and reducing consumption, reducing the need to produce as much material from virgin or primary sources. Many materials, especially metals such as aluminum, require significantly less energy to recycle than to extract from their ores. Recycling of metals and minerals also reduces the land use impact of mining. Recycling of paper saves trees, and recycling of plastic reduces consumption of fossil fuels.

Unlike the usual SCOR “return” processes, recycling often sends materials far back up the supply chain, such as when scrap metal is re-melted, re-alloyed, and reformed by primary metals companies who are deep-tier suppliers to OEMs. In other cases, the recycling process creates a raw material for an entirely different supply chain. Gillette sold excess shaving foam materials to companies that grow turf for commercial uses; scrap from U.S. Pampers wipes was converted into upholstery filling; and sludge from toilet tissue paper in Mexico was converted into low-cost roof tiles (Procter and Gamble Co., 2014).

Companies can also recover useful energy from materials than have no other economic value. Unilever built anaerobic digesters that convert food waste and other compostable materials into biogas, which is then burned to provide renewable energy heat for industrial processes (Food and Drink Federation, 2013). As of 2013, Unilever had 30 biomass boilers globally supplying more than 7% of its renewable energy, with six more planned in Latin America, Africa and Asia (Unilever 2013). Similarly, P&G’s Budapest plant making feminine hygiene products started selling excess material as a fuel for a local cement kiln (Procter and Gamble Co., 2014). Such practices reduce the solid and liquid-waste emissions of the factory and reduce the need for energy consumption from other sources.

Through product recycling and waste-to-energy initiatives, Unilever achieved zero non-hazardous waste to landfill at more than half of its sites (~130 sites) around the world (Dunnage, 2012). But then the company added a second-level goal of reducing the amount of waste materials (as a percent of production volume) that needs to be recycled or otherwise handled by these various recovery processes (Dunnage, 2012). In essence, Unilever recognizes that recycling is not a "best" practice, only a "less bad" practice than discarding these materials. The better best practice is to reduce the stream of materials that need recycling. The highest-level sustainability metrics encode the top-level goals of reducing total consumption of natural resources and total emissions back into the environment. Lower-level sustainability metrics might encode material efficiency, such as the percentage of consumed natural resources that make it into the final product. Whereas a company wants to minimize total impact, it also wants to maximize the amount of product or value generated by the impact that it incurs.

3.6. Sustainability as a Side Effect of Cost Savings and Lean Initiatives

Lean manufacturing can improve environmental performance without even focusing on it. Reducing waste, eliminating defects (and the material that goes into making them) and eliminating over-production and extra inventory (which has to be discarded in many cases) yield significant environmental benefits on both the consumption and emissions portions of the impact equation. Such ideas, in one way or another, are already included in the "Make" process. De-materialization is typically defined as "reduction in the quantity of materials used and/or the quantity of waste generated in the production of a unit of economic output" (Cleveland and Ruth, 1988). In many cases, the strategic goal of sustainability aligns with the goal of reducing costs, in that reducing the material content of a product, reducing waste, reducing energy consumption, and eliminating defects will improve both sustainability and cost. Such efforts, where corporate financial goals are aligned with environmental goals are typically referred to as "eco-efficiency" in the environmental literature.

For example, Unilever's efforts to reduce waste reduced costs, too. "Without any significant capital investment, we've saved more than EUR 70 million through the zero-waste program," said Tony Dunnage (2012), Group Environmental Engineering Manager for Unilever. Most of those savings came from reducing waste at production facilities, Dunnage said. In 2012, Unilever reduced its manufacturing waste to half of its 2008 total. Reducing the volume of discarded material also reduced the value lost into the waste stream (Dunnage, 2012). By 2013, Unilever had been reducing its waste by 75,000 tons annually, translating into significant cost savings.

4. Supplier Sustainability

A company's total environmental footprint depends on the total environmental footprint of all its suppliers.[7] In many cases, most of this footprint occurs upstream. One would naturally expect that this will be the case for retailers and, indeed, Wal-Mart estimates that over 90 percent of its emissions are rooted in its upstream supply chain (Environmental Leader, 2010). However, this is also true for many manufacturers. Using its Environmental Profit and Loss (EP&L)

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[7] A few categories of outside-the-company environmental impacts can be offset by the company such as through the purchase of carbon offsets, remediation of damaged lands, or reforestation. Yet such offsets are controversial in the environmental activist community and cannot entirely undo the effects of toxic emissions, environmental destruction, or species extinction.

framework, PUMA (2010) calculated that 94% of its total environmental impact occurs at its suppliers and their suppliers, throughout the supply chain.

4.1. Enabling Sustainability in the Deep Tiers

The ResponsibleSCOR framework expands the scope of responsibility of "Plan" and "Enable" over the sourcing process to include sustainability-related processes beyond traditional sourcing processes, such as supplier selection, negotiations, contracting, ordering, scheduling deliveries, receiving, verification, transfer, and supplier payment authorization.

The environmental impacts incurred by a supplier almost never appear in the product itself. Although the Greenpeace (2010) parody of Nestle's KitKat ad implied the candy bar contained dead orangutans, neither Nestle nor the consumer could determine the sustainability of the candy bar or its ingredients by laboratory analysis. Palm oil from sustainable sources is indistinguishable from palm oil sourced from clear-cut areas. Sustainability depends not just on what the supplier delivers but on how the supplier sources, makes, and delivers the product. That is, the supplier's processes matter. Companies can ensure the sustainability of suppliers through practices such as developing supplier codes of conduct, audits, and training.

Moreover, sustainability depends on the actions farmers, miners, and others who extract the Earth's natural resources, all of whom may be deeper-tier suppliers over which the company may have no direct knowledge or oversight. Rather than the "source" process of one company influencing just the "Make" and "Deliver" processes of the supplier, the company's "source" process must influence the supplier's "source" process, the supplier's supplier's "source" process, and so on all the way back to the extraction echelon.

Sustainability practices such as supplier codes of conduct are one reason why the SCOR "Enable" process must expand to encompass the entire supply chain. "Enable" includes sub-processes for managing business rules, contracts, and performance. Moving towards environmental sustainability depends on pushing business rules, contract terms, and performance management practices out from the company and into suppliers who, in turn, push those sustainability practices to the next tier. That is, the "Enable" process in the supplier becomes linked to the "Enable" process of the company.

4.2. Supplier Code of Conduct

To manage how suppliers run their businesses – pushing sustainability upstream – companies use codes-of-conduct such as IKEA's "IKEA Way" or IWAY (IKEA, 2012). The document includes requirements (not just guidelines) regarding child labor, worker safety, fire prevention and environmental sustainability. The company first developed these rules in 2000 and gave its suppliers time until the end of 2012 to reach full 100 percent compliance (Skjelmose, 2012). When the deadline passed, 75 of the company's approximately 1,100 suppliers fell short of the requirements. They were immediately dismissed. "They were close — they were very close. Most of them were on 98, 99 percent fulfillment, actually, of the code of conduct, but we said it's only 100 percent that counts," said Jeanette Skjelmose, sustainability manager for IKEA. "So, even if they were only missing one question, we said, 'Sorry. We have to end the contract with you.'"

In another example, Section 9 of PepsiCo's Global Supplier Code of Conduct (2014) states: "The potential environmental impacts of daily business decision-making processes should be considered along with opportunities for conservation of natural resources, recycling, source reduction and pollution."

4.3. Supplier Sustainability Audits

Most supplier sustainability metrics, which are then aggregated into the company's sustainability metrics, are derived from suppliers' responses to a questionnaire. To "trust and verify," the code of conduct has to be coupled with an audit regime. IKEA executes about 1,200 audits per year, most of which are performed during surprise visits by IKEA audit staff. The company requires that its suppliers furnish the names, addresses and global positioning system (GPS) coordinates of their sub-suppliers' facilities. "We need to have it because we need to be able to go there unannounced," Skjelmose said. IKEA's supplier contracts include a clause that allows any of its 80 staff auditors to make surprise audits in suppliers' facilities and those of the suppliers' suppliers. Skjelmose explained, "if they should deny us access, we regard that as a violation of the IWAY norm. We classify that as a work deviation and stop orders from that supplier immediately."

To increase leverage, and reduce audit and compliance costs, companies often develop industry-level codes of conduct and audit protocols. The Electronics Industry Citizenship Coalition (EICC), for example, created the Validated Audit Process (VAP). The VAP "provides companies assurance in identifying risks and driving improvements and robust management systems for labor, ethics, health, safety and environmental conditions in the Information Technology supply chain" (EICC, 2012).

Note that the SCOR model process of "Source" focuses strictly on the day-to-day operational process of scheduling product deliveries, receiving product, verifying product, transferring products, and authorizing supplier payment. There's nothing in "Source" about supplier selection, supplier relationships, or supplier management. Deciding who to source from is part of the "Plan" process but managing supplier performance and supplier contracts (including supplier blacklists) is scattered across several part of "Enable."

4.4. Supplier Sustainability Training

Rather than just rely only on punishing offenders, many leading companies provide training for suppliers and work with them to develop environmentally responsible processes. For example, Philips Electronics includes training and capacity-building in its supplier development. Philips sustainability experts visit suppliers regularly, providing classroom training as well as on-site consulting. Specifically, in 2012, the company held special training sessions about the EICC code of conduct, as well as safety training and chemicals management (Philips, 2013). Similarly, Timberland, which is part of VF Corporation, works with its suppliers on training, development and implementation of sustainable environmental systems. Timberland focuses on capacity-building and implementation of sustainability metrics, in addition to worker and community engagement (Timberland, 2015).

Other companies embed supplier training in the questionnaire or certification documents. For example, Starbucks developed Coffee and Farmer Equity (C.A.F.E.) Practices in collaboration with the NGO Conservation International and with an independent third-party company, Scientific Certification Systems (SCS). C.A.F.E. standards use a scorecard that encodes more than 100 specific coffee-growing and processing practices that enhance the sustainability of coffee plantations (Starbucks Coffee Company, 2014). These practices include: a ground cover of mulch and nitrogen-fixing cover crops that improve the soil, regular analysis of soil and coffee plant to check nutrient levels, erosion reduction, buffer zones for water bodies, biodiversity practices, and restrictions on pesticides. "Zero tolerance" items define high-priority forbidden practices and "extra point" practices give plantations some flexibility to excel on different dimensions. In addition to incentives of becoming a potential Starbucks supplier, the program also includes direct monetary incentives for high-scoring growers and processors of green coffee (Craves, 2010).

The development and upkeep of a code of conduct, managing audit processes, and working with suppliers through training and knowledge sharing are all lower-level processes of the "Enable" processes that manage issues such as business rules, performance, contracts, compliance, risk, and the overall supply chain relationships.

5. Customer Sustainability

Unlike the companies mentioned above that have high upstream footprints, for many other companies the majority of the environmental impact takes place when the consumer uses their product. This category includes products such as vehicles, appliances, and electronics, but it also includes other less obvious items. For example, over 96% of the environmental impact of body-wash soaps sold in Germany comes from their use. This is the result of the energy it takes to heat water for a shower. Similarly, Boots, the UK pharmacy, estimated that 93% of the environmental impacts of its shampoo occur in the consumer use stage, again due mainly to water heating. And an independent LCA of the impact of washing clothes determined that 75% of the greenhouse gas impact was due to washing and drying, not the manufacturing of the appliances or the detergent (Koerner et al., 2011).

5.1. Communications for Sustainability

To influence the consumer use phase, companies can either create more sustainable products and/or resort to consumer marketing. For example, several companies have come up with dry shampoo that can be used with no water, such as Pantene's "Dry Shampoo Root Reboost" and many others. Procter and Gamble is selling "Tide Coldwater" which obviate the need to heat the water for laundry. Some corporate communications is designed to alert customers to these alternatives. Others are aimed at changing consumers' behavior. Unilever's (2012) Sunlight Living Challenge created the "2 minute shower song" to challenge people to conserve water by finishing their shower before the song ends. Similarly Ariel's "Turn To 30˚C" campaign (Marketing Society, 2010) is aimed at convincing consumers to use less-than-boiling water for their laundry. Other companies can embed communications to improve sustainability into the product itself. Some models of automobiles provide feedback to the driver on average fuel efficiency or whether the vehicle is being operated in an eco-friendly manner. Hybrid vehicles, especially, offer constant feedback on energy use, battery status, and fuel-efficient use of the engine.

All these are example of extending the responsibility and associated metrics of environmental performance beyond the tradition supply chain and into the use phase of the product. As such they are part of the "Enable" level-1 process as it extends beyond the corporate boundaries.

5.2. Encouraging Post-Consumer Recycling

Post-consumer recycling depends on consumers not simply throwing end-of-life products into the trash. To make recycling as easy as possible, companies pre-create convenient recycling channels. For example, Hewlett Packard supplies a return envelope with each of its new toner cartridges so customers can easily return the used cartridges. In another example, office supply store Staples (2013) has set out battery collection bins at its retail locations. As noted in Section 3.5, recycling extends the "Return" process but is quite different from other types of returns in that the product is usually broken down in raw materials rather than refurbished to a finished goods state.

5.3. "Servicizing"

One business practice that helps the manufacturer ensure sustainable use is for the producer of the product to take over management of the product on behalf of the customer. That is, the company converts the product into a service in which the manufacturer retains ownership and control over the product. With *Servicizing,* also known as performance-based selling, companies provide their customers with functionality rather than products: climate control instead of air conditioners; data processing services instead of computers; or a contracted number of landings instead of airline tires. Selling services transfers the responsibility for performance, maintenance and replacement to the supplier. It can create incentives for manufacturers to maintain the product carefully, increasing its useful life, and even to design their products for durability and extended life. Both careful maintenance and proper design lead to reduced material intensity by reducing consumption levels.

In some cases, the service can supplant the physical product and its environmental impacts by replicating the functionality of the product via more sustainable means. Xerox changed from being a copier manufacturer to "the Document Company" in 1994. Instead of focusing on making and selling copiers, Xerox started focusing on the information processes supported by office copiers, which was the distribution of documents in large organizations. It launched a consulting arm, Xerox Global Services, to help customers improve their document-related business processes. A central goal of the consultants' analysis was an increase in workers' productivity and a reduction in the number of copiers. Although Xerox's change was motivated more by technological shifts than by environmental concerns, the conversion from a copier manufacturer to a document service company reduced the number of copiers manufactured and reduced Xerox customers' consumption of paper and toner as well as emissions of solid waste. New revenues and new customers from the service offset lost revenues from declining copier sales.

Servicizing increases the role of the "Deliver" process in achieving the company's value proposition to customers. Servicizing exemplifies a higher-order of dematerialization and the relationship between SCOR physical delivery processes and processes in other parts of the company that deliver consulting, computing, and in-person services, often to the same customer base. Taken to the extreme, a company might entirely divest its manufacturing – eliminating the environmental impact of the supply chain by eliminating the supply chain.

Yet dematerializing has its limits, in that even pure computing services depend on highly impactful electronics manufacturing supply chains and electrical power production. Moreover, many service industries such as restaurants, healthcare, and entertainment rely heavily on physical supply chains as a key element of the service.

5.4. Mediate Consumer Re-Use

Consumer re-use of long-lived products is not a new phenomenon. Car dealers and individuals have always bought and sold used cars, and vintage clothing stores carrying previously-worn garments have been in business for a long time. Naturally, large consumer capital purchases, such as real estate, have always been subject to re-use. The scale of such secondary markets grew with the expansion of Internet use with sites such as eBay, Craigslist, and many others. However, in all these cases, the manufacturer was not involved nor did it see itself as responsible for secondary transactions. This all changed with the growing environmental awareness of the last decades.

In 2011 Patagonia, the California high-end clothing company partnered with eBay to sell its used products. It placed a full-page ad in the *New York Times* on Black Friday — the day after Thanksgiving in the U.S. and the biggest shopping day of the year — telling consumers "don't buy this jacket" (Patagonia, 2011). The ad was encouraging consumers to also consider buying a Patagonia used item instead, through the company website. To have their items listed on Patagonia's web site, eBay sellers must pledge to "help wrestle the full life out of every Patagonia product" by buying used when possible and selling their Patagonia clothes when they're no longer in use (eBay, 2013). By May 2013, when Patagonia and eBay expanded their partnership to include sales in Europe, 60,000 eBay members had taken the pledge and resold more than 53,000 garments (eBay, 2013). That number did not include garments sold by members who hadn't taken the pledge. The eBay-powered portal was part of the clothing company's larger "Common Threads" initiative, which aims to promote conscious consumption and increase resale, reuse and recycling of Patagonia products.

In many ways such practices may be out of scope of SCOR because they involve Marketing and Sales to a large extent. Yet, these practices involve the storage and movement of used merchandise and thus could be construed as part of the "Enable" process – especially when done in concert with a supplier or a retailer.

6. Conclusion

In general, the SCOR model provides a flexible framework for an organization to design and manage its supply chain in accordance with the corporate's strategy. Yet some categories of strategic objectives call for extensions of the SCOR framework to handle the interplay between these objectives and supply chain processes. Sustainability is an emerging strategic objective, but one that involves a holistic rather than organization-focused performance attribute of supply chains. Sustainability is often strongly affected by business and consumer practices outside the four-walls and direct management control of any one company in that supply chain.

ResponsibleSCOR is one possible framework for extending the SCOR model to both measure this new dimension of performance across the supply chain and to reflect the key role of more distant players in the supply chain. Reducing the consumption of natural resources upstream and waste emissions at the post-consumer downstream of the supply chain calls for an expanded scope of supply chain practices, especially those that manage or enable sustainable behavior among supply chain partners. New, emerging practices can help companies improve their own environmental performance, as well as that of their suppliers, their customers, and consumers to improve the sustainability of the entire supply chain.

The need to cross-connect the SCOR model's framework for organizations both up and down the supply chain reflects the natural cross-connection of companies in the global economy and their impacts on the biosphere.

As more companies use an extended framework such as ResponsibleSCOR to manage supply chain sustainability, these interconnections will begin to close the loop by which post-consumer materials re-enter the deep pre-consumer supply chain. The ResponsibleSCOR extensions can help morph the linear-chain SCOR model into a circular economy sustainability model. Holistic management of supply chains will help ensure holistic improvements of standards of living around the world without overtaxing the natural capacity of the planet.

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