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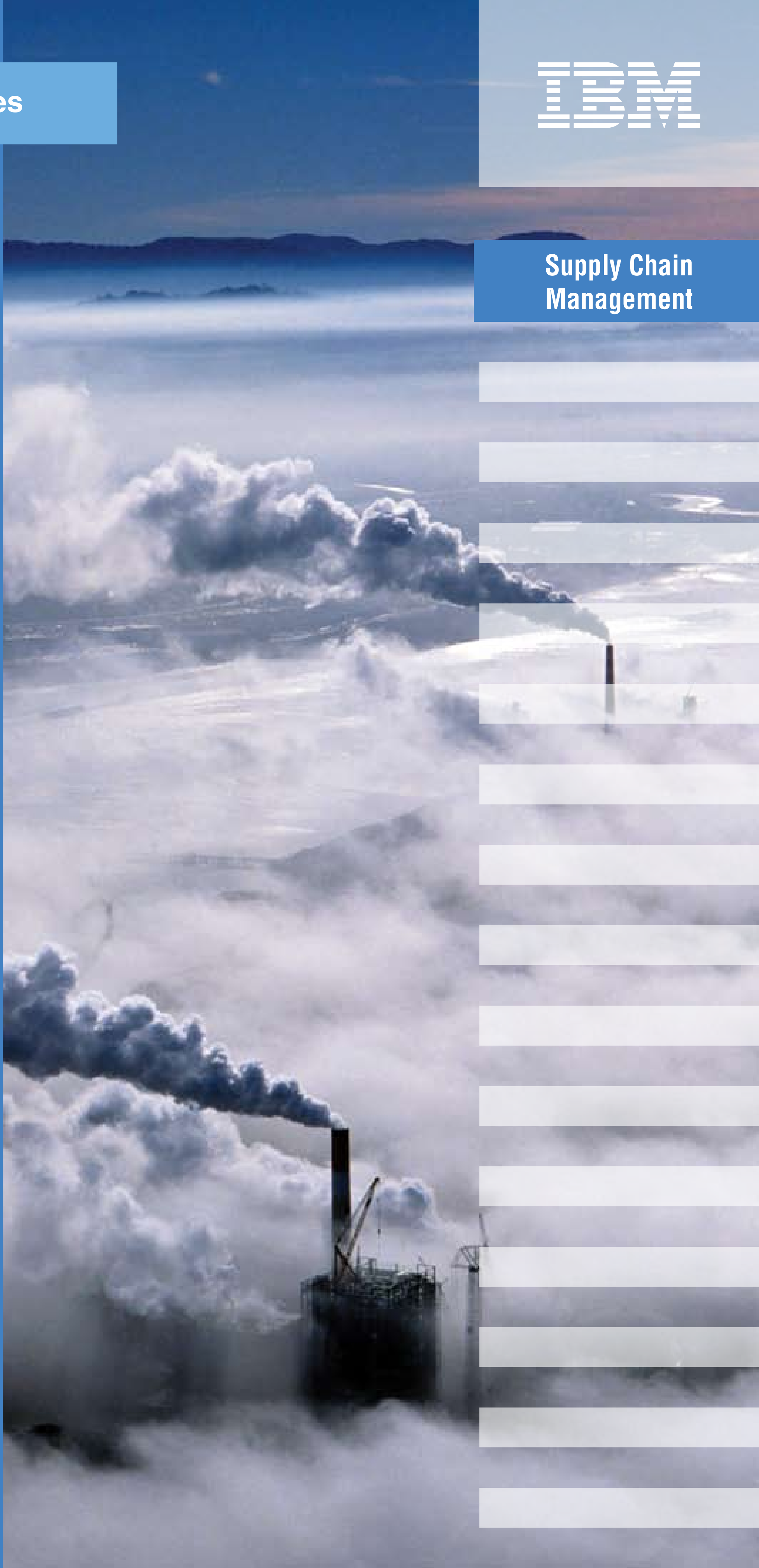

Supply Chain Management

Mastering carbon management

Balancing trade-offs to optimize supply chain efficiencies

IBM Institute for Business Value

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Mastering carbon management

Balancing trade-offs to optimize supply chain efficiencies

By Karen Butner, Dietmar Geuder and Jeffrey Hittner

As the planet heats up, so do regulatory mandates to reduce greenhouse gas emissions worldwide. Much of the opportunity to address CO_2 emissions rests on the supply chain, compelling companies to look for new approaches to managing carbon effectively – from sourcing and production, to distribution and product afterlife. The trade-offs in the supply chain are no longer just about cost, service and quality – but cost, service, quality and carbon. By incorporating carbon reduction into their overall SCM strategy, companies can help reduce their environmental emissions footprint, strengthen their brand image and develop competitive advantage.

Introduction

The volume of global trade has more than doubled in the last decade – reaching six times the rate of growth of the world's gross domestic product (GDP) during the same period of time.[1] This phenomenon has been facilitated by relatively cheap energy, with low attention given to the impact on climate change. Consider that the global fleet of oceangoing ships accounts for more CO_2 emissions than any of all but six countries worldwide.[2] Yet, none of this environmental impact is reflected in shipping prices.

With estimated economic damage of about US$85 for each ton of carbon dioxide, capping greenhouse gas (GHG) emissions and putting a price tag on them became inevitable.[3] Indeed, under the European Union emissions trading scheme (EU ETS), such a setup is already in effect for certain industries. Similar schemes are popping up across the United States in separate groups of states and in other major industrial economies worldwide.

Going forward, firms should expect to be charged for their CO_2 emissions. And most certainly, this charge will force a change in the way companies run their supply chains. Common practices of the last century – like long-distance airfreight, small batch size, just-in-time concepts and energy-intensive production in countries with low environmental standards – will likely go by the economic and political wayside. Reducing the supply chain's carbon footprint will become an inescapable obligation.

The choice will be either to delay – or to embrace – the climate challenge as a chance to restructure the supply chain for the economic and environmental good. The companies that act now can reap advantages that may be denied to those that wait for the regulatory hand. These benefits include the mindshare of a growing ethical consumer market; the attraction and retention of top talent; and more sustainable growth overall.

The goal will be to optimize supply chain products, processes, information and cash flow in the face of four main factors, or "trade-offs": *cost*, *service*, *quality* and *carbon emissions*. The supply chain, we must emphasize, will not fundamentally change. But with carbon as an added criterion, the economics behind traditional practices *will* change, and optimizing the supply chain will become more complex.

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Trade-offs to reduce carbon output

"Green" supply chain management begins with recognizing the environmental dimensions (such as carbon emissions, demand on energy and other natural resources). Succeeding at it will ultimately require supply chain executives and managers to balance numerous options and master a new challenge: optimizing supply chain products, processes, information and cash flows in light of four main factors: cost, service, quality and now, carbon emissions.

Options

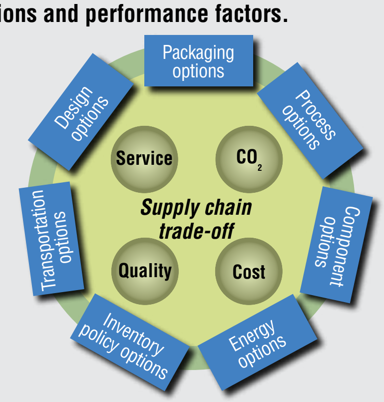
Different areas of the supply chain present options for becoming more sustainable and managing carbon better. Yet all of these areas, as well as various sourcing, production and distribution processes, are typically closely interconnected and dependent on one another. For instance, local SCM optimization efforts may adversely (and often unforeseeably) affect other areas of the supply chain – limiting options for improvement and stymieing the attainment of an overall optimum result.

Therefore, carbon management, energy consumption and other environmental concerns should be analyzed and approached from a *holistic* viewpoint – evaluating overall performance goals (cost, service, quality and carbon) in terms of their relationship to one another.

In component supply, manufacturing/assembly and distribution, there are a number of options for reducing carbon and cost simultaneously (simultaneity being, of course, the hallmark of the best solutions). A trade-off model looks at these areas and considers all of the factors in the "wheel" – design, packaging, processes, components, energy, inventory and transportation (see Figure 1).

These options represent the "levers" available to influence cost, quality and service, as well as GHG emissions. The more carbon becomes incorporated into these levers, the more "seamlessly green" a business can appear. This can make products more attractive to the growing share of ethical consumers in the marketplace today, and the company more appealing to the next generation of employees intent on making a positive impact on the world around them. For each of these

FIGURE 1.
A trade-off model takes into account various options and performance factors.



Source: IBM Research and the IBM Institute for Business Value.

levers, there are examples of options in the areas that need to be addressed. These include:

- *Design:* Materials selection; energy efficiency; durability; upgradeability; ease of disassembly; recyclability; disposability; virtual product development
- *Packaging:* Size; reuse/recycling; materials (corrugated box, Styrofoam, plastic and the like); documentation/manuals
- *Processes:* Order fulfilment; manufacturing; transportation; quality control; organizational management; demand/supply planning
- *Components:* Substitutes, sourcing, location, supplier rationalization
- *Energy:* Fossil fuel-based (oil, natural gas); renewable energy-based (ethanol, solar, wind); other (nuclear, geothermal)
- *Inventory policy:* Safety stocks; lot sizes; planning frequency; replenishment programs (just-in-time, vendor-managed inventory, direct store delivery)
- *Transportation:* Modes, shipment frequency, load consolidation, routing.

Trade-offs in action: Logistics and distribution

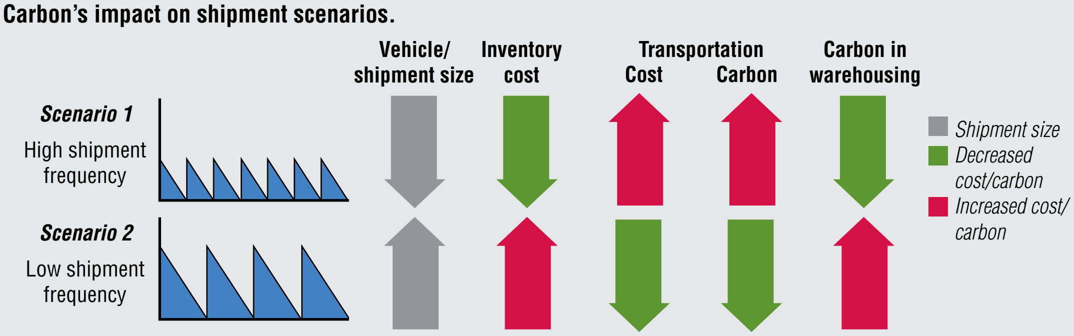
A typical SCM challenge is to strike the right balance of transportation, process and inventory policies. CO_2 reduction adds another factor to this quest (see Figure 2).

Shipment consolidation

Shipment consolidation is one of the major opportunities to reduce the carbon footprint. Quantifying the impact of shipment frequency on cost and carbon can help to establish an inventory replenishment policy that addresses business needs *and* reduces environmental impact. Many current just-in-time and direct customer delivery inventory policies require smaller loads to be shipped more frequently (see Scenario 1 in Figure 2).

This heightened service level frequently reduces the inventory pipeline while increasing transportation costs and carbon. A change in policy – to fewer but larger shipments – may be made at the cost of higher inventory levels and associated storage, and could affect service levels (see Scenario 2 in Figure 2). But increasing energy and carbon costs will likely shift the balance of current policies in this direction.

FIGURE 2.
Carbon's impact on shipment scenarios.



Source: IBM Research.

Today, optimizing the supply chain requires making – and balancing – trade-offs in key areas.

Sourcing locations

Supplier distance can impact component cost, carbon emission and inventory – all of which can be *quantified* to evaluate an organization's procurement strategy and determine the need for modification to address environmental dimensions. Until now, a typical procurement strategy looked at landed cost – the actual, total cost of importing an item (vendor expenses, transportation charges, duties, taxes, broker fees), plus relevant logistics costs (acquisition, storage, movement, disposition of goods). Taking into account carbon-based risks and costs, "environmental" landed costs may rebalance local and global sourcing strategies – leading to a new "trade-off point."

Modes of transportation

In addition to reducing transport miles, a company can factor into the equation a focus on low-carbon transport options – train, plane, ship and truck all have different carbon trade-offs between cost, service level and carbon impact. As governments begin to invest in greener transportation infrastructures and discourage those modes with greater environmental negative impact, companies can evaluate a new spectrum of transportation options. Businesses must take a careful look at the inherent fuel economy/emissions levels of various alternatives – factoring in load planning for efficient use of vehicles. They must optimize truck and container size, and weigh speed limitations against carbon impact, vehicle maintenance requirements, driving patterns and even driver training.

Network optimization

Network optimization strategies can be revised to address the additional carbon variable and its impact on facility placement, manufacturing, distribution and transportation operations. This can also encompass distribution facilities' role and sizing, transportation options, sourcing and procurement policies, and inventory placement. Network optimization models will thus address carbon-based parameters while simultaneously working to meet objectives regarding overall costs, inventory pipeline and service level achievements (see trade-off in distribution sidebar).

The trade-off in distribution: Service and cost versus emissions

Determining ideal warehouse locations for a distribution infrastructure used to be mainly a question of service level and cost. However, for some, this decision now takes into account carbon emissions. The following examples describe projects that effectively balance carbon with other factors.

For a defined service level, an American bath and kitchen products manufacturer was able to reduce carbon emissions by 34 percent by relocating its warehouses. While optimizing for emissions alone could have achieved up to 40 percent of carbon reduction, that decision would have resulted in a disproportionately higher relocation cost.

For a European white goods distributor, reductions of 14 percent of emissions was achieved with an optimized distribution network, balanced for all 4 criteria and achieving a 98 percent service level. In this case, the trade-off solution is two percentage points short of its maximum achievable level of CO_2 reduction.[4]

Policies relating to transportation, processes and inventory should consider both business and environmental repercussions.

Taken as a whole, these factors – modes of transportation, warehouse and supplier locations, shipment frequency and routing – must be *re-analyzed* against the cost of carbon to determine the new optimal trade-off point. Including carbon in the mix will require deep computing, plus mathematical and analytical capabilities.

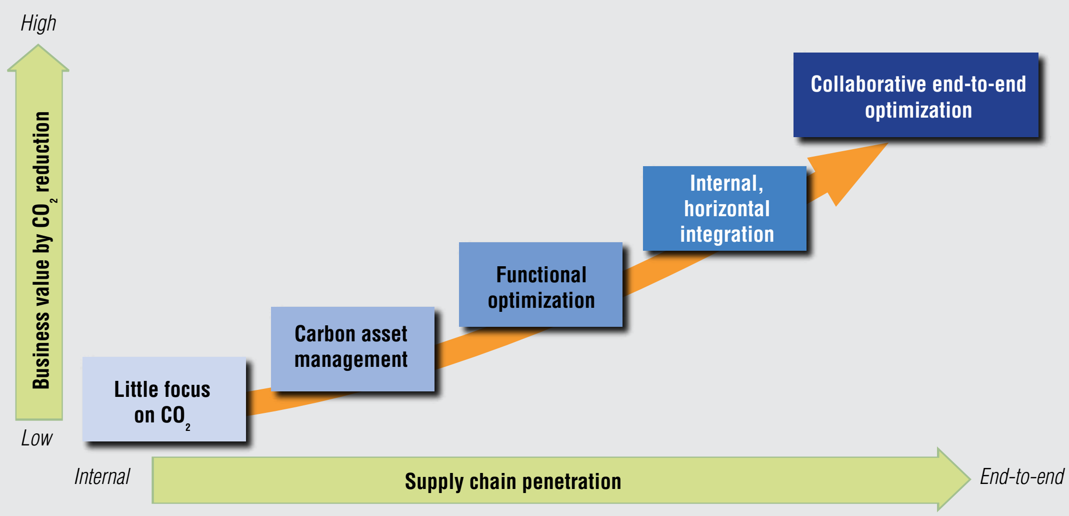
As a 2008 IBM Institute for Business Value Global Corporate Social Responsibility survey shows, a third of today's companies are required by their business partners to adopt or acquire new carbon management standards.[5] Businesses well positioned for the 21st century are those that can quantify cost and carbon, and provide partners and customers with a level of knowledge and management that can help differentiate them in the marketplace.

Five steps to mastering carbon in the supply chain

The fact that carbon trade-offs will complicate the supply chain emphasizes the need for organizations to address this issue in a number of ways – and fast. There are specific steps companies can take to limit GHG emissions – from easy-to-implement local improvements to complex optimizations that involve an extended supply chain. The further these activities extend and integrate across the supply chain, the greater leverage and control they will have over carbon emissions (see Figure 3).

While an all-encompassing approach may have the highest potential for improvement, it also introduces more complexity, more coordination effort and more implementation time. "Low hanging fruit," such as point solutions for reducing carbon, may have less overall improvement potential, but can show an immediate return on investment. These efforts can even lower certain expenditures to the point of enabling additional, more integrated carbon-reducing investments. We therefore recommend a step-wise approach:

FIGURE 3.
Supply chain carbon mastery model.



Source: IBM Institute for Business Value.

1. Diagnose and assess.
2. Implement asset management and realize point solutions.
3. Address emissions in supply chain functions.
4. Find the optimum solution for integrating across functions.
5. Collaborate with supply chain partners to realize overall potential.

1. Diagnosis and assessment

Today's global economy and the interdependencies between a company and its partners (suppliers, contract manufacturers, logistics providers, financial and tax entities, and customers) require businesses to gain a *holistic* understanding of the carbon impact of their entire supply chain – from supply strategy, to distribution and warehouse management, to product operations and customer service. Using a carbon diagnostic that evaluates each high-level supply chain component according to a simple set of carbon statements and key performance indicators, a company can begin to define its own maturity level, identify gaps and set target levels.

Priority areas for taking action are determined by combining the results of the assessment, the maturity level, the ease of taking action and the strategic positioning. The higher the strategic importance of an activity and the bigger its performance gap, the more important it is to take action.

2. Carbon asset management

Much of the potential for directly reducing carbon emissions lies in a supply chain's facilities and assets. Warehousing, machinery, vehicle fleets and data centers, for instance, can consume huge amounts of energy. Investing in facilities with a low carbon footprint and energy-saving equipment offers an effective first step with a defined return on investment (see the Catalyst Paper Corporation sidebar). Implementing carbon-based asset management helps ensure that the most direct savings potential concerning emission and cost can be realized.

Reducing energy consumption in paper production

Catalyst Paper Corporation, a Canadian pulp and paper company, uses its own by-products (biomass) to power its operations. It also regains heat from effluence to warm process water and thereby further reduce its carbon emissions. Together with efficiency gains and a switch to natural gas, the company has lowered its GHG emissions by 70 percent and its energy use by 21 percent since 1990. In 2005 and 2006 alone, the company saved US$4.4 million through a 2 percent reduction in fuel consumption.[6]

3. Functional optimization

Each supply chain function can make a specific contribution to help reduce GHGs. Generally speaking – and depending on the carbon diagnostic results and "green" SCM strategy – the ability to reduce CO_2 emissions is typically greater when measures are taken early in the process (see Figure 4). Considerations in product design, customer fulfillment and even reverse logistics offer a range of functional optimization opportunities.

When considering any functional optimization, there is always the question of whether outsourcing could be an option for helping to lower carbon emissions. In many parts of the supply chain, outsourcing has led to

Targeted, step-by-step efforts to reduce GHG emissions can have a big impact, and offer an immediate return on investment.

FIGURE 4.
Environmental optimization potential in supply chain functions.

Strategy
Setting goals, integrating with business strategy, focus areas, policies, funding

Product design	Planning	Sourcing	Production	Logistics	Service and end-of-life
• How can product design make better trade-offs between design requirements, including carbon footprint? • What tools and practices should be employed by companies wanting to establish leadership? • What are the carbon impacts throughout the product's lifecycle, and how can they be minimized upfront through smart design?	• How can the total network be optimized, considering service, cost, "green" trade-offs? • What is the CO_2 impact from various inventory concepts and planning methodologies? • Are there opportunities to reduce cost and carbon emission at the same time?	• How can we best measure a supplier's carbon impact (product, packaging, upstream logistics) and ultimately comply with carbon reduction requirements? • What sourcing strategies will result in a better trade-off of cost, service level, quality, carbon emission? • How should we evaluate carbon offsets?	• What operations strategy (facility location, operating model) provides the best trade-off between cost, service, carbon? • Is there a role for sustainable factory/facility management? • Can lean manufacturing and Six Sigma approaches be used to manage carbon? • Is there a role for manufacturing execution software in the management of carbon?	• What distribution network strategy (facility locations, sizes, transport modes) provides the best trade-off of cost, service and carbon? • How can packaging be reduced and recycled? • What is the impact of increased load consolidation, and is this practical? • What role can alternative fuel or power sources play?	• How can field service operations reduce carbon footprint with better routing and parts inventory tracking? • Is there a mechanism to drive continuous design improvement from service back to product design and engineering? • Are all strategies employed to reduce landfilled materials: reuse, refurbishing, recycling, secondary markets?

Asset management
Sustainable facilities management; green building and energy carbon footprint asset management; asset utilization (Realtime data on energy usage, i.e., carbon dashboard)

Finance
Paperwork reduction; environmental cost accounting; environmental tax benefits tracking

Source: IBM Global Business Services.

more specialization and efficiency (contract manufacturing is one example). However, these activities are often more geographically dispersed – increasing transportation needs. A service provider is typically better positioned in terms of scale (and consequently reducing more greenhouse gases). This is especially true for third-party logistics providers, who can offer carbon-optimized bundling for transportation needs. Although it always needs to be evaluated closely – outsourcing of specific supply chain functions may indeed lead to reduction in the overall carbon output.

4. Internal horizontal integration

Depending on the type of supply chain, the most pertinent areas for carbon reduction vary, as does their complexity. With today's globally distributed supply chains and customized products, that complexity has often increased to the point where specific functional improvements have a very limited reach. In contrast, a *horizontally integrated approach* across functions permits much greater leverage.

Similar to the "design for manufacturability" or "design for serviceability" concepts, *design for environment* takes emissions into account. This includes carbon's impact on sourcing, manufacturing and distribution. *Modified* *packaging* for reducing transportation efforts is another commonly practiced approach for various supply chain areas. The dairy foods case (see the Friesland Coberco Dairy Foods sidebar) is an example that spans all functions, from product design to transportation. Late customization, as in this case, can mitigate the effect of dispersed operations, but it requires businesses to address carbon management in an integrated manner across supply chain functions. Also, as this example shows, integrating carbon management can strengthen an organization's brand image.

Reducing CO_2 emissions in this way often means balancing the consequences in different areas. For example, as discussed in the section on trade-offs, one of the possible compromises is between production batch sizes and energy-saving transportation batches, or inventory levels.

An integrated view of a dairy supply chain: Friesland Coberco Dairy Foods

Baby food has lately become a highly diversified product. In the past, only three product lines existed – one for each age group. Today, a multitude of product varieties is available, including those for increasing resistance or treating allergies. Netherlands-based Friesland Coberco Dairy Foods produces, packs, ships and maintains inventory of baby food – all from different locations. To reduce transportation efforts, the company is now adjusting its recipes and its production processes to create variants of a basic product. Specific ingredients are added at a late stage in the supply chain. This has the potential to cut needed inventory – and thereby transportation – by an estimated 127,000 miles per year, with corresponding carbon reductions.[7]

5. Collaborative, end-to-end optimization

While internal horizontal integration may increase leverage, the *full* potential for reducing emissions can be attained only if all players in the supply chain pull at the same string and collaborate on *end-to-end optimization* (see the Tesco sidebar).

Integrated packaging design at Tesco

Glass is the biggest single contributor to the packaging weight that UK retailer Tesco passes on to its customers. By prodding the industry to produce lighter-weight wine bottles, Tesco reduced its annual glass usage from one single supplier by 2,600 tons – a 15 percent saving.

An estimated 4,100 tons of carbon emissions were avoided by importing "new world" wines in bulk and bottling them in lightweight glass in the UK. Improving product design not only produced savings for the glass manufacturer, it also reduced the carbon emissions through the entire lifecycle of a glass bottle.[8]

Ideally, a lifecycle carbon assessment serves to determine a comprehensive approach for reducing carbon along the supply chain. In practice, however, end-to-end lifecycle assessments are often lengthy and costly undertakings. Pragmatic approaches that focus on a few key collaborative steps among partners in the supply chain can lead to tangible results comparatively fast, and with a potentially higher return on investment than a single player can achieve.

Coordinating inventory and transportation among supply chain partners to reduce carbon impact can dramatically reduce mileage. Combining these efforts with low-emitting transportation options can further

Integrating carbon management into SCM strategies and processes can be a best-of-both worlds situation for businesses, consumers – and the environment.

lower carbon output. Following this approach, Unilever, together with first- and second-tier suppliers and supermarkets, for instance, identified possible avoidance of 2.7 million miles per year.[9]

Another example of collaboration among supply chain partners is returnable packaging, which (unlike disposable packaging) is intended for repeated use and can significantly reduce the impact of packaging-related carbon. This has proven effective for material supply in automotive and fresh-produce retailing supply chains.

Based on a defined environmental strategy, common ground should be cultivated with partners – especially in the areas of product design, packaging and logistics. Once the opportunities for improvements in carbon management are clear, collaboration and end-to-end supply chain optimization – based on balancing the desired outcomes in cost, service, quality and environment – can create a winning situation for all parties.

Conclusion

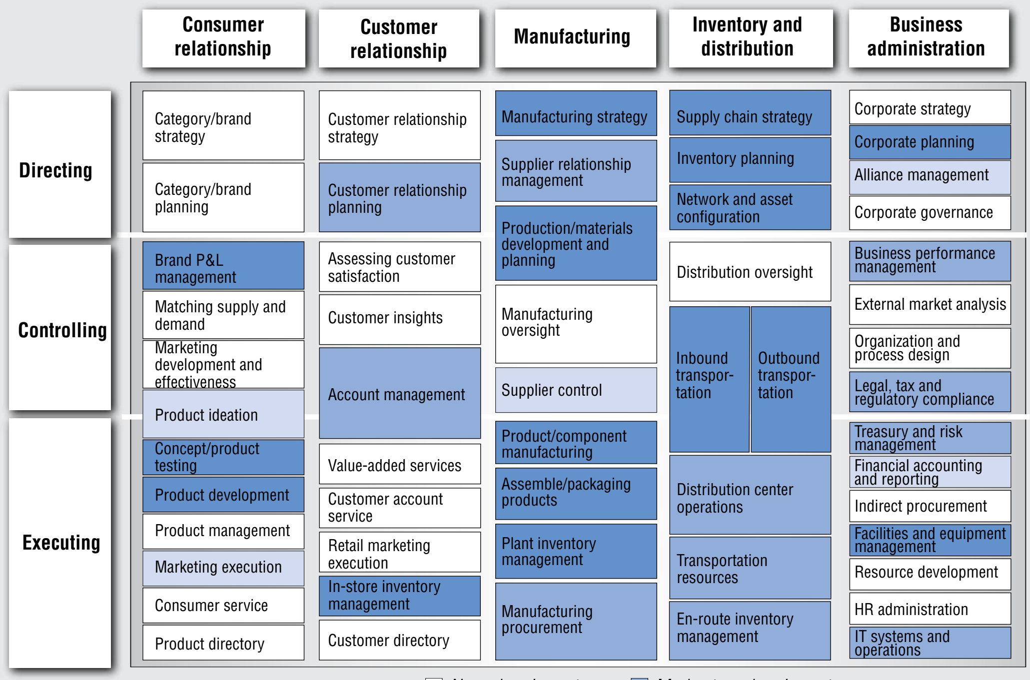
Future regulations will no doubt prescribe ways to reduce carbon emissions. By then, the cost of compliance – in every way – may be much greater. The time to tackle carbon emissions in the supply chain is now, when more options are still available to gain true and lasting advantages. This is one of those rare occasions when doing the financially smart thing, and doing the right thing for consumers and the environment are one and the same.

The ideal solution is to strike the optimal trade-off between the desired states of cost, service, quality and carbon – a classic optimization challenge that a combination of mathematical analytics, deep computing and industry expertise can help resolve. For companies that are not yet equipped to tackle every hurdle, we recommend the intermediate steps discussed above to help achieve specific GHG reductions.

As you begin to tackle the issue of carbon management in your supply chain, there are several key questions to think about:

- What is the model, or "heat map," of your current carbon footprint? What processes within the enterprise and the extended enterprise are carbon-intensive? Figure 5 depicts a possible carbon heat map based on the "deconstruction" of a company's business model into discrete processes and functions.
- What are the key green indicators that you should be measuring? What are the current targets and thresholds for improving and/or meeting regulatory requirements?
- What are the critical trade-offs, and the constraints and considerations, regarding the reduction of carbon in your supply chain – all while maintaining service and quality, and easing the cost impact? Remember, the goal is not to reduce carbon at the cost of your traditional supply chain objectives; it is to make carbon reduction a *means* for achieving those objectives.
- If pursuing a collaborative approach for carbon management, how do you get partners on board, and how will you share risk, responsibility and value?

FIGURE 5.
A sample carbon heat map.



Source: IBM Institute for Business Value.

As companies move from a reactive to a proactive stance in managing carbon, they can convert a cost issue into a growth opportunity. Taking into account traditional concerns about quality, service and cost, a comprehensive carbon-management strategy can help organizations develop more sustainable growth opportunities, maintain competitive differentiation, and strengthen their brand image. In an age of heightened corporate scrutiny and social responsibility, the companies that turn the tables on the carbon challenge could well be the leaders in the 21st century global economy.

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