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Calculating sustainability in supply chain capitalism

Susanne Freidberg

Abstract

This paper examines the recent rise of life cycle assessment (LCA) as a supply chain governance tool. Many big brand retailers and manufacturers, as well as a number of governments, see LCA as a potentially valuable means to measure, communicate and thereby improve the 'sustainability' of material goods. The paper's arguments are threefold. First, the appeal of LCA's quantitative and seeming holistic methods must be understood in light of certain tensions and imperatives endemic to contemporary supply chain capitalism. Second, this appeal is tentative; it is far from clear that LCA can capture the complexity of products' 'lives' in measures that are simultaneously practical, legible and scientifically credible. Third, current public- and private-sector sustainability initiatives involving LCA offer opportunities to explore the increasingly important roles of scientific and technical expert communities in supply chain governance.

Keywords: governance; sustainability; supply chains; standards; environment; metrics.

Social scientists and investigative journalists are no longer alone in their efforts to trace and reveal the hidden 'lives' of everyday goods. Many makers and sellers of those goods now also analyse their cradle-to-grave existence. To do so, they draw on life cycle assessment (LCA), a technique that quantifies and compares products' multiple impacts on human and environmental well-being. Although LCA is not new, in recent years it has attracted unprecedented attention from both companies and governments. They see it as a potentially valuable means to measure, communicate and thereby improve the 'sustainability' of material goods ranging from groceries to skyscrapers. They seek to

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realize this potential on national and global scales. LCA's proponents envision a world economy transformed – and sustained – by new, truer metrics of value (Chouinard *et al.*, 2011; Goleman, 2010). By contrast, LCA has received almost no attention from social scientists. This is remarkable given not only its rising prominence in the business and policy worlds, but also current humanities and social science interest in the 'liveliness' of material objects (Bennett, 2009; Marres & Lezaun, 2011; Whatmore & Braun, 2010). LCA assesses precisely this, albeit from a very different perspective on material life.

This paper makes three related arguments. First, LCA's current cachet reflects imperatives and tensions within supply chain capitalism, Anna Tsing's term for the contemporary profit-seeking activities of corporate retailers and manufacturers, and for the highly diverse and dynamic global value chains these activities have created (Gereffi & Lee 2012; Tsing, 2009b). Second, corporate efforts to quantify products' lifelong environmental impacts mark an important, underappreciated, yet fragile shift in supply chain governance strategies. It is fragile partly because, as Barry (2002) has shown for other 'metrological regimes', LCA's calculations cannot always capture complex realities in a credible, legible and practical fashion. Nor can they resolve debates over sustainability itself as a normative goal (Sneddon *et al.*, 2006). If anything, attempts to incorporate these metrics into supply chain governance could have the reverse effect.

The paper's third point is methodological. It aims to show how analyses of supply chain governance can benefit from closer attention to the epistemic communities that both create and take shape around tools of governance. Such an approach has long characterized scholarship in science and technology studies (STS), including much work on market rules and devices (Callon, 1998; Callon *et al.*, 2007; Knorr-Cetina & Preda, 2001). To date, however, STS has engaged little with the expertise and technical practices that have made supply chain capitalism possible (though see Busch, 2007; Loconto, 2010). Drawing on a larger ethnographic project, this paper thus examines how LCA serves both in an emergent regime of metrics-based governance[1] and as a source of livelihood and professional identity for members of a loose-knit international expert community spanning academia, industry and consulting. The research has included more than 60 in-depth interviews with LCA practitioners as well as with representatives of companies, government agencies and NGOs that use, promote or (in the case of certain NGOs) criticize LCA. It has also entailed attendance at several international conferences on LCA and business sustainability, university-level coursework in LCA and analyses of the written materials pertaining to LCA and its supply chain applications. These materials range from the field's peer-reviewed journals to the 'green business' press, corporate sustainability reports and online forums where LCA practitioners exchange advice, data and opinions.[2]

The paper begins with a brief overview of LCA's purposes, methods and assumptions. The next section takes up the recent history of supply chain capitalism and examines the forces behind the rise of LCA as a governance tool

distinct from the voluntary standards and certifications already in wide use. Two major initiatives, the US-based Sustainability Consortium and France's national environmental 'footprinting' scheme, illustrate its growing prominence. The final section turns to the challenges these initiatives have encountered and the tension they expose in the broader project to promote supply chain sustainability by means of life cycle metrics. On one hand, the seemingly comprehensive information generated by such metrics is also often costly, complex, contradictory and altogether unhelpful for the type of 'informed choices' expected of chain actors. On the other hand, LCA's critics point to all the concerns its models overlook. This tension suggests that LCA's numbers may continue to raise more questions than they answer.

Life according to LCA

As an environmental assessment technique, LCA dates back to the early 1970s. At a time of heightened concern about pollution, waste and energy scarcity, manufacturers such as Coca-Cola wanted information about precisely how their products performed in these areas and also, often, how they compared to competing products (Hunt & Franklin, 1996). Engineers and physical scientists conducted many of the earliest studies. Since then, LCA has become closely linked with industrial ecology, an interdisciplinary field populated by (among others) engineers, environmental toxicologists and ecological economists (Allenby, 2006). LCA's traditional focus on manufactured goods has also since broadened to encompass food and other 'bio-based' products (Canals *et al.*, 2011). That said, LCA views product 'life' through a mechanistic rather than a biological lens; flows of matter and energy define its beginning, end and passage from one stage to the next (Lifset, 2006).

Up to a point, LCA's wide-angle view of product life cycles resembles social science perspectives on global commodity and value chains as well as the popular journalistic genre of 'commodity biographies' (Bair, 2008; Wenzel, 2011). Indeed, exposés and critical documentaries that claim to reveal a product's 'whole story' – the online hit *Story of stuff* (Leonard, 2007) is just one example – count among the reasons why companies adopt LCA: they want their own whole story. But whereas critical narratives highlight the unequal and often exploitative power relations that connect supply chain actors, LCA models and aggregates discrete impacts, during each stage of a product life cycle and in multiple environmental and human health categories. Importantly, LCA assumes that these impacts are 'site-independent' and steady state: in other words, its models do not take account of where they happen or over what timeframe (Stevenson, 2010).

Calculating such impacts requires data on the inputs, outputs and processes that comprise a product's life, from raw material extraction through disposal. Data collection is often the most time-consuming part of an assessment, especially if a product contains many novel or internationally sourced materials.

Some data come from companies within a product's supply chain (provided they are willing to share it) and the rest from specialized LCA databases or other secondary sources (Rebitzer *et al.*, 2004). Almost always, practitioners must make do with incomplete or questionable data. Their assessments are expected to acknowledge the resulting uncertainties and qualify the findings accordingly. But it is the numbers rather than their provisos that give LCA studies their authority, both in and beyond the world of practitioners.

This authority is grounded in what Porter (1966) calls 'mechanical objectivity'. This does not mean that the assessments themselves are mechanical; LCA experts would be the first to argue otherwise. Rather, it means that at least in principle they derive and use numbers according to standardized rules (Espeland & Stevens, 2009, p. 420). For LCA, a set of International Standards Organization (ISO) standards defines the field's most widely recognized rules (Finkbeiner *et al.*, 2006). In addition, more specific 'product category rules' aim to ensure that similar products – all shampoos, for example, or all frozen vegetables – are assessed the same way (Ingwersen & Stevenson, 2012; Schenck, 2009).

In reality, these rules do not ensure uniformity. They are not always practical to follow nor do practitioners always agree on their interpretation. Nonetheless, the very creation of the ISO standards in the late 1990s gave LCA a degree of much-needed credibility. Previously, practitioners' varied approaches to modelling product life cycles made LCA appear unscientific and prone to co-option. This was especially true during the 'diaper wars' of the early 1990s, when Procter & Gamble and the diaper laundering industry each commissioned disposable-versus-cloth life cycle studies and reached opposing conclusions (Lehrburge *et al.*, 1991; Little, 1990).

As defined by the ISO standards, LCA is not just 'science-based' but also extraordinarily comprehensive in that it assesses the 'entire life cycle of a product' as well as 'all attributes or aspects of natural environment, human health and resources' (ISO, 2006, pp. 6–7). This official definition in turn supports companies' claims that life cycle studies of their products reveal the real, actual, true or whole picture of environmental impact and that these studies generate 'plain facts' (i.e. quantitative results) rather than fuzzy boasts about eco-friendliness or naturalness (Arratia, 2011).

LCA's authority matters beyond marketing claims. Especially in northern Europe, the traditional centre of much LCA research and training, many companies use the technique primarily for internal purposes. They rely on its broad perspective to avoid unintended consequences in product design and sourcing, and to manage potentially costly or brand-damaging environmental 'hotspots' in product life cycles.[3] A food processor considering a shift to local raw materials might discover, for example, that local production required more water and fertilizer, thereby outweighing any environmental benefits from reduced transport. Often LCA reveals that the most needed improvements lie outside companies' direct control. Life cycle studies of many food products locate the heaviest environmental impacts on the farm, not (as often assumed)

in transport or packaging. It follows that food manufacturers and retailers should prioritize improving the efficiency of their agricultural suppliers (Mogensen *et al*., 2011; Muñoz *et al*., 2010; Roy *et al*., 2009). For laundry detergent, by contrast, consumers' hot water use accounts for most of the impacts, meaning companies should focus on developing and promoting cold-water alternatives (Martin & Rosenthal, 2011). LCA's numbers, if credible, help first to direct and then to justify these supply chain decisions.

Similarly, some governments now look to LCA to guide and legitimate procurement, eco-labelling and other sustainable production and consumption policies. As France's environmental reporting scheme (described below) demonstrates, such policies promote greener supply chains not through direct regulation, but rather through the numbers companies must generate, disclose and compete around. Governing through numbers is clearly not new (Espeland & Stevens, 2009; Porter, 1996). Much of their appeal lies in seeming both impartial and easy to interpret. In the context of supply chains, diverse decision-makers (policy-makers, company managers, consumers) do not need to share expertise or interests in the environmental processes represented by LCA's numbers in order to agree that less impact is better than more.

Norms versus numbers in supply chain governance

For sociologists and geographers, the analysis of supply chains (also sometimes referred to as value or commodity chains) offers insights into globalization's governance (Bair, 2008; Gibbon & Ponte, 2008; Gibbon *et al*., 2008). One central strand of research examines how private standards and certification systems serve to 'normalize' supply chains – that is, to bring practices and sites into compliance with specific norms (Gibbon *et al*., 2008). Many standards define the criteria for certification labels, such as those for organic, Fairtrade and 'cruelty-free' products. Many others are relatively invisible to consumers but widely used by retailers and big brand manufacturers, such as the GlobalGAP standard for agriculture, the Forest Stewardship Council's (FSC) forest management and chain-of-custody standards, the Ethical Trading Initiative's labour 'Base Code' and a wide array of ISO standards (von Hagen, 2011). Although legally voluntary, these business-to-business standards often give suppliers the choice of either compliance or lost business. By doing so, they help retailers and other lead firms reduce supply chain risks (i.e. due to inferior or tainted products, exposés or lawsuits), build investor and consumer trust in their brands and thereby compete on factors other than price (Busch, 2011).

As many scholars have noted, supply chain standards and certification bodies exemplify neoliberal governance (Busch, 2010; Gibbon & Henriksen, 2012; Higgins & Hallstrom, 2007; Ponte *et al*., 2011). They are generally created by non-state entities (with some exceptions, such as national organic

standards), they govern transnational supply chains that economic liberalization first encouraged and they are expected to fill the gaps opened by state deregulation (Mayer & Gereffi, 2010). In addition, many standards respond to popular concerns about neoliberalism's consequences for human and environmental well-being. European supermarkets formed GlobalGAP (originally EurepGAP) during a period when repeated food scares undermined consumers' confidence in their increasingly globalized food supply (Casey, 2009). The garment industry's adoption of labour standards, similarly, followed anti-sweatshop activism and media scandals (O'Rourke, 2005). Significantly, such standards are the products of corporate consortia, round tables and other 'multi-stakeholder initiatives' involving unprecedented cooperation between direct rivals and otherwise antagonistic parties (Brassett *et al*., 2010; Fransen & Kolk, 2007; Fuchs *et al*., 2011). These precompetitive initiatives highlight how standards serve to legitimate both individual brands and, more broadly, the globalized sourcing and governance activities that constitute supply chain capitalism.

What interests Tsing about supply chains are not standards *per se*, but rather the many unstandardized places and labour forces that supply chains encompass. Informal and contract workers, smallholder farmers and old growth forests count among many possible examples. Unlike the most successful firms of the mid-twentieth century, such as US auto manufacturers, today's supply chain capitalists not only tolerate but thrive on diversity, ecological as well as cultural and socioeconomic. Whether because they cheapen production, add value or both, 'pockets of disadvantage and difference' profit supply chains' lead firms, who therefore should not want to standardize them (Tsing, 2009a, p. 361). Many such pockets reflect the uneven development that capitalism has always needed and reproduced (Smith, 2008). Even so, they often have their own defenders, as Tsing's earlier work on rain forest activism shows (Tsing, 2005).

Tsing's emphasis on the persistent, even constitutive diversity of supply chains does not clash with perspectives that stress standards' increasing reach and regulatory power. Standards can differentiate as well as standardize, as Busch (2011) observes, and some explicitly aim to protect biological or cultural diversity. Examples include the FSC and Marine Stewardship Council standards for forests and fisheries, and the standards for 'terroir' products and sustainable tourism (Barham, 2003; Font & Harris, 2004). Other standards are simply weak or unenforced, leaving untouched diversity manifested as, say, workplace discrimination. And of course many supply chain sites do not comply with any standards, whether because they have failed or, operating in relative obscurity, have never had to do so. Tsing's archetypal supply chain capitalist is Walmart. Despite the immense power the retailer exercises over even its biggest suppliers, she argues, 'there are clear demarcations between what Wal-Mart wants to control (e.g., prices, marketing, logistics) and what Wal-Mart does not want to control (e.g., labor arrangements, environmental practices, subcontractors' investment strategies)' (Tsing, 2009b, p. 156).

For much of the retailer's history, few observers would question this statement. The contrast between Walmart's draconian logistical requirements on one hand and utter disregard for supply chain labour and environmental abuses on the other was well documented by the mid-2000s (Fishman, 2007; Gereffi & Christian, 2009; Petrovic & Hamilton, 2006). But by then the company had also experienced the type of oppositional campaigns, lawsuits and scandals that supply chain capitalism, by its very 'disorganized' nature, can hardly escape (Tsing, 2009b, p. 172). Walmart also had evidence that the bad press was beginning to drive away shoppers (Humes, 2011, p. 52).

Under these circumstances, the then-CEO Lee Scott decided on a change of course. In an October 2005 speech to employees, he declared that Walmart should use its clout to 'make this country and this earth an even better place for all of us: customers, Associates, our children, and generations unborn' (Scott, 2005). Announcing a long list of environmental and social goals, the speech marked the launch of Walmart's 'unlikely green revolution' (Humes, 2011). It also signalled to suppliers that it would soon demand more from them than just the cheapest possible goods.

Initially these demands targeted a narrow range of products and certification standards. Although many European retailers had adopted similar strategies years before, Walmart's size gave it the potential to transform entire industries (Winston, 2009). By early 2012, for instance, three-quarters of its wild and farmed seafood products had been certified as sustainable by third parties (Walmart, 2012). The retailer had also become the world's biggest buyer of organic cotton (Humes, 2011, pp. 134–5).

Walmart's later embrace of LCA responded to two late-2000s trends in corporate supply chain governance. First, as high-profile retailers and manufacturers came under pressure to take action on climate change, many began measuring their products' carbon footprints (PCFs) – that is, their cradle-to-grave embodied greenhouse gases emissions (Bolwig & Gibbon, 2009; Newell & Vos, 2011). The British retailer Tesco announced in 2007 that it would carbon label all of its 70,000 product lines, while the French chain Leclerc added a CO_2 tally to shoppers' checkout receipts. Although not all companies' PCF activity was aimed at consumers (who, according to early market research, did not understand or heed the information anyway (Upham & Bleda, 2009)), their demands for new kinds of information about their products rippled across sectors and supply chains (Marks & Spencer, 2010; Walker, 2008). LCA practitioners thus saw the carbon footprint as a foot in the door. They saw it as a 'myopic' metric by itself (since it speaks to only one environmental concern), but one that encouraged 'life cycle thinking', and led at least some companies to undertake more complete assessments (Finkbeiner, 2009; Weidema *et al.*, 2008).

Second, the late 2000s saw a proliferation of sustainability standards generated by a 'multiplayer melee' of environmental NGOs, industry groups and consultancies (Unruh & Ettenson, 2010, p. 110). Although many large companies participated in this process, they also reported frustration at the

sheer number of standards (ISEAL Alliance, 2011, p. 15). Many standards overlap with one another, yet most cover only one stage of a product's life or a narrow range of concerns, such as whether coffee qualifies as 'bird-friendly' (Golden *et al.*, 2010; Kaenzig *et al.*, 2011). For suppliers, repeated certifications cost time as well as money, and exclude many smaller operations entirely (Kaplinsky, 2010). Vetting numerous standards and certification agencies also costs retailers and big-brand manufacturers, potentially slowing progress towards stated goals (as with Walmart's seafood pledge, above). And ever-more eco-labels and related product claims foster consumer confusion and distrust, leading to concerns that too much 'eco-babble' could destroy the very market that standards and labels were supposed to cultivate (Golden *et al.*, 2010; U.S. Green Product, 2009).

Corporate manufacturers and retailers will probably not abandon sustainability standards any time soon. They could, however, de-emphasize these standards in favour of other supply chain governance tools, such as LCA. A 2011 *Harvard Business Review* article co-authored by Walmart consultant Jib Ellison and two top staff at Patagonia (widely considered a 'sustainability leader') predicted such a shift. They summed up standards' shortcomings with reference to the home products company Ikea:

> Currently Ikea uses FSC-certified wood in 24% of its solid wood products. To reach its goal of 100% of its solid wood meeting its standards for sustainable logging, it will need to work with additional 'preferred sources' that have their own certifications. And even then, it will have to turn to still other certifiers and standards bodies to manage the other impacts of those wood products, from the greenhouse gases emitted by their manufacture and transportation to their end-of-life disposal. A dizzying array of certifications has cropped up. . . . Those standards compete and overlap in multitudinous ways.
>
> (Chouinard *et al.*, 2011, p. 59)

The authors presented standards as flawed predecessors to the 'objective' life cycle data increasingly used by companies to rank materials and products. One of their primary examples was Walmart, or rather a larger corporate initiative that Walmart launched. In July 2009, the retailer announced it would create a 'sustainability index' based on multiple cradle-to-grave environmental and social impacts and covering, in theory, every product on its shelves. Information collected from suppliers would feed a vast database and eventually provide consumers with 'a simple rating' of products' overall sustainability. Although it was (and remains) unclear how, where and when such ratings would appear, Walmart emphasized they would inform its own purchasing decisions. Similar to other companies' stated rationales for carbon footprinting, then, Walmart described the index as a force for improvement in itself. Not only would it enable consumers to make greener choices; competition among suppliers to better their scores would also drive innovation and the adoption of best practices (Walmart, 2009).

Walmart illustrated this latter point in a video series about 'the secret life' of individual store-brand products. Although posted on public sites (Walmartstores.com as well as YouTube) the videos send a direct message to suppliers about their expected roles in cutting emissions, waste and costs. 'The secret life of sour cream', for example, tells of a cradle-to-grave study that identified dairy farms as the 'hotspot' in the sour cream supply chain. The video shows Walmart's supplier farms addressed the problem by building methane digesters that would not only reduce emissions but also generate electricity, thus saving $250 million across the supply chain. 'The secret life of sliced turkey', similarly, features a major supplier who figures out how to process more turkey while cutting water use, transport and packaging, saving $1 million annually. A spokesperson for the company notes that this improved efficiency has helped 'grow our partnership with Walmart' (Walmart, 2011).

From the beginning, Walmart emphasized that it would not build its index alone. Indeed it could not, given that it needed other companies' data. So, together with several major suppliers, the retailer founded the Sustainability Consortium (TSC), a nominally academic venture jointly run by the University of Arkansas and Arizona State University. Charging membership fees of up to $100,000 per year, TSC recruited companies that wanted a say in how it measured sustainability, or at least wanted to ensure their ongoing business with Walmart. As of late 2012 TSC membership included more than 80 companies, among them many major retailers and manufacturers (Kroger, Tesco, Safeway, Marks & Spencer, Dow Chemical, General Mills, Unilever, Monsanto among them). It also included the US Environmental Protection Agency, Britain's DEFRA and a handful of large NGOs (such as the Environmental Defense Fund, WWF and Care).

Several LCA consultancies also became members. Together with university affiliations, they allow TSC to boast of its access to the 'world's top Life Cycle Analysis scientists'.[4] Some of the LCA experts involved are in fact world renowned. TSC sought their help and approval in developing assessment methods far simpler and faster yet also more comprehensive than traditional LCA – covering, for example, supply chain labour conditions – all while maintaining scientific credibility.[5] It has proven a tall order.

When Walmart first announced its index, the US business media described it as 'huge', 'audacious beyond words' and 'a giant leap for Planet Earth' (Kanter, 2009; Makower, 2009). Yet barely two weeks after the retailer's press release (and receiving much less news coverage) the French government passed a law committing it to a remarkably similar goal: universal, multi-criteria *affichage environnemental*, or the reporting of product environmental footprints. The law declared French consumers' right to 'honest, objective and complete environmental information' about everyday products (Boy, 2010; Government of France, 2009). This information would be based on products' life cycles, include more than CO_2 emissions, and cover, in theory, all consumer goods sold in France, including imports (Cherruault, 2010; Vergez, 2012).

Unlike TSC, the French environmental footprint project aimed from the start to include small enterprises. This has required developing a national database of French raw materials (with the help of LCA practitioners recruited from Switzerland, where the technique is more established), as well as online footprinting tools specific to certain industries, such as baking. The project also entailed the creation of several sector-specific working groups, each responsible for how to 'footprint' different types of products, from food to cosmetics to books. In certain working groups, such as food and agriculture, most of the participants started off with no previous knowledge of LCA. Many were concerned about what it would cost them to find and report data. Producers of beef and other goods known to have large environmental footprints made clear their opposition to the entire scheme.

The government first delayed the law's implementation and then revised it to start in July 2011 as a voluntary one-year trial, with 168 companies chosen to participate. The companies ranged in size from major multinationals (Nestlé, Levi-Strauss) to a family-run village bakery. During the trial the government granted companies considerable leeway: except for obligatory greenhouse gas emissions reporting, they could decide which products and what environmental impacts to measure and how and where to report them. More than half opted to post information on their websites or smart phone applications rather than on labels. They also chose to report varied impacts (i.e. water quality, biodiversity, natural resource use) in varied forms. Some used quantitative measures, others letter grades, others rankings on green to less-green spectrums. All this variation meant that consumers could not compare similar products.

The French government is expected to decide in autumn 2013 whether to proceed with the original plan of mandatory product environmental footprinting. Reports from the Ministry of Sustainable Development suggest that footprinting would likely remain voluntary over the short term, in part because the government is not yet prepared to implement such a mandate. It would also undoubtedly face both domestic and international industry opposition, and possibly charges of violating World Trade Organization principles. At the same time, the environmental footprinting of products looks likely to spread; in mid-2013 the European Commission launched its own three-year trail, modeled after France's own (European Commission, 2013).

Such policies might seem at odds with the non-state governance associated with supply chain capitalism. It is not, for a few reasons. First, Europe's national governments have historically used various incentives and 'soft' regulations to encourage responsible corporate activity (Antal & Sobczak, 2007; Gond *et al.*, 2011). France's environmental policies have promoted market-driven 'sustainable consumption' since the early 2000s (Rumpala, 2011). Second, environmental footprint policies make companies responsible for much of the work involved in governance. It falls to them to collect the necessary data about their products (or to hire consultancies to do so), and to determine how to improve their environmental performance. More generally, such policies assume that

market forces will drive this improvement, as consumers choose 'greener' products and companies compete to provide them.

Consumers' role in this process is far from proven. LCA practitioners as well as their corporate clients often express doubts about consumers' appetite even for simplified environmental labelling. Such scepticism has if anything increased; commentators who in 2009 cheered consumers' access to ever-more information about their products' attributes now question whether they understand or care about it (Winston, 2012).[6] Consumer confusion counted among the reasons why British supermarket Tesco decided to abandon carbon labelling in January 2012 (Quinn, 2012).[7] Nonetheless, even sceptics see the imperative for companies to disclose life cycle-based product information as a transformative force. As one Paris-based consultant put it, 'It's not even about the label. It's about reporting and having to publish. One of the things that happens when you publish is that you don't want to look bad'. Through LCAs of their products, companies find out not only whether they might look bad, but also how they might look better.

TSC and France's environmental footprint scheme count among several major initiatives that have called attention to product life cycles and thereby to LCA. Once obscure, by 2009 the technique had become a 'hot topic' in the business world (Makower, 2009). Specialized LCA consultancies have multiplied and grown over the past few years.[8] In addition, many major standards certification and auditing agencies (PricewaterhouseCoopers, Ernst & Young, KPMG, Scientific Certification Systems, Deloitte) have added carbon footprinting and LCA to their services. Corporate attendance at LCA conferences and numerous practitioners' own accounts confirm that business interest in the field has sky-rocketed.

At one level, this interest marks simply corporations' latest efforts to demonstrate good citizenship (Matten *et al.*, 2003). Like their commitments to various standards, LCA helps companies appear accountable to government, investors and customers – meaning not just consumers but also retailers. Indeed, as with standards, many companies first undertake life cycle studies of their products because their retail clients want the information. In Europe especially, many also see such studies (again, like standards) as preparation for possible future regulatory requirements.

At another level, LCA represents a very different approach to supply chain accountability than existing standards regimes (Busch, 2011). Two differences deserve emphasis. First, standards prescribe practices and invoke norms. Created by institutions claiming expert or moral authority (or both), they dictate what counts as safe, fair, cruelty-free, climate-smart or simply 'Grade A' or 'Extra Large'. Standards set bars for actors and objects. LCA, on the other hand, generates numbers. The numbers result from many judgement calls, as discussed earlier, but do not themselves judge. In other words, standards make a company look accountable by certifying that its products meet expected norms. LCA, however, does so by measuring products' impacts – or, more precisely, by allowing a company to say they have been measured. The

accountability conferred by LCA, then, hinges primarily on transparency and the competencies required to demonstrate it (Bardeline, 2011; Mason, 2008; Skaar & Fet, 2011).

Second, this notion of accountability implies different meanings of improvement and even of sustainability itself. Applied to supply chains, standards' normative goals usually target specific sites, practices and product qualities. LCA, like other forms of accounting, shifts attention from norms to numbers, in this case those numbers that represent products' lifelong environmental impacts. How those numbers improve matters less than by how much. Put somewhat differently, 'best practices' matter less than measurably better results. But, because LCA studies tend to locate the heaviest impacts in the production and use phases (and very little in even the biggest 'big box' stores), they also prioritize those areas for improvement.

Measurable increases in product eco-efficiency, then, become the chief markers of progress toward sustainability. Retailers and brand name manufacturers find this an appealing yardstick. Improving eco-efficiency does not challenge their basic business model; it does not require consumers to buy less. As 'The secret life of sliced turkey' video puts it, 'in the end, all this effort is about the customer in the store. It's about saving her money, and making sure that every dollar she spends is a vote for a better world' (Walmart, 2011). This effort is also about finding new customers elsewhere in the world. Efficiencies undertaken in the name of sustainability at home, in other words, may also help Walmart expand into low-income, high-growth markets abroad (Dauvergne & Lister, 2012).

The focus on quantifiable eco-efficiency also does not necessarily challenge yield-maximizing practices where they are otherwise controversial, such as in agriculture, livestock production and forestry. It is no surprise that TSC's members include major agrichemical and forest products companies as well as an association of commodity crop producers. Their products generally do not qualify for, say, organic or FSC certification, but by certain life cycle measures of eco-efficiency, they perform relatively well.[9] As one agrichemical industry representative explained in an interview, his company (a seller of pesticides and genetically modified seeds) had joined others to develop metrics for assessing agricultural products across their supply chains because it 'didn't want sustainability defined as organic'. In other words, the company did not want a standard that bars certain practices and inputs to threaten its markets.

In sum, the current cachet of LCA in corporate and policy-making circles must be understood in light of the characteristics and governance challenges of twenty-first-century supply chain capitalism. Not even Walmart can still afford the degree of selective indifference that once characterized the Walmart model. While states' capacity to regulate globalized supply chains remains limited, high-profile companies face increasing pressure to account for their products' impacts on human and environmental well-being, including in parts of supply chains outside their direct control. LCA generates information that can potentially help them do this, through both disclosure itself and the resulting

pressure on suppliers to improve. It offers a form of accountability that appears more comprehensive than individual certification standards yet poses fewer restrictions. Not least, LCA addresses companies' need for a suitable 'framing' of goals and solutions. As Heiskanen puts it, 'The central role of LCA-based tools and models is not in solving problems, but in constructing problems in a distinctive way' (2002, p. 434). More precisely, it constructs a product and its impacts as the problem, which suggests technical solutions. Big-brand companies' role in driving product demand and obsolescence does not figure into LCA's big-picture perspective.

'The life cycle approach to sustainability is a fragile thing'

The sub-heading above quotes an LCA expert involved in TSC. His view is not unique nor does it apply only to the Consortium's activities. Despite booming corporate interest in LCA, not even its most bullish advocates claim that it has become a standard governance tool. Some major multinationals boast teams of in-house LCA experts, but most do not. Initiatives to promote LCA's wider use abound, but all have far to go. Veteran LCA consultants observe that many companies commission studies of their products, then end up shelving the results. At LCA conferences and in private conversations, practitioners often express both excitement about their field's rapid growth and trepidation that they might collectively 'screw up'. A keynote speaker at a 2011 conference in Berlin invoked the 'hype cycle' model of technology adoption, noting that high expectations of LCA put it in 'a very dangerous position' – potentially just before widespread disillusionment.[10]

What explains LCA's fragile status? The expert involved in TSC provided two answers to this question. For many companies, he said, LCA 'seems too complicated' as a tool, while as a field 'it seems too fraught with conflict and dispute'. It is complicated because so are products' lives. Even raw unpackaged goods pass through several life stages, and all have environmental impacts. Most of these impacts can only be modelled, not directly observed or validated. Products' relations with each other as well as with human lives further complicate the modelling. Consider liquid milk: it may come from a cow fed on soybean meal (a co-product of soybean oil), a farm that sells off bull calves as meat and a dairy processor that turn its cream into butter or cheese. An LCA of a carton of milk must determine not only how much each of these life stages contributes to different environmental impacts – i.e. global warming, resource depletion, acidification – but also what proportion of the impacts to assign to the milk itself, rather than to its co-products. This is known as the allocation problem (Ekvall & Finnveden, 2001).

This is just one simplified example of the complexity that LCA practitioners confront in a typical assessment. They are well aware that non-experts often cannot make sense of their models or the resulting numbers. Even the field's best-known textbook – *The hitch hiker's guide to LCA* (Bauman & Tillman,

2004) – alludes to the comic science fiction novel *The hitch hiker's guide to the galaxy* (Adams, 1979), in which a supercomputer, asked to explain the 'meaning of life, the universe and everything', calculates for 7½ million years and then answers '42'. The textbook's authors offer no solution to the problem of baffled clients. Instead, they warn against the temptation to present clients with oversimplified or overstated results.

In their own assessments, practitioners navigate the complexity of their subject matter by referring to the ISO standards, precedents in the LCA literature, clients' priorities, their peers and, not least, the practical constraints of time and money. Yet, despite the development of increasingly sophisticated modelling software, LCA remains a costly and time-consuming technique. A single product study can take months and cost tens of thousands of dollars, much of it spent tracking down acceptable data. Globalization and rapid product innovation have not made the task any simpler; many products, components and raw materials now come from countries where reliable data are scarce.[11] Plenty of green consultancies offer simplified and cheaper assessments, but they lack the rigour needed for labelling or other product claims. TSC itself, despite no lack of top-notch LCA expertise, completed only seven product assessments during its first two years.

Companies find LCA especially frustrating when they pay large sums for ambiguous results. Practitioners, referring to *The hitchhiker's guide*, often joke that the answer to all the questions asked of LCA is always the same, and it is not 42, but rather, 'it depends'. Corporate clients may not find this answer funny, but it is often true. Whether one product appears environmentally superior to another often depends on which impacts and life cycle stages one looks at. It also depends on which data a study uses, and what it assumes about all that is unknown or indeterminate about a product's life. Ambiguity and uncertainty are a real part of the 'whole story' of material goods, but not necessarily the part that companies want to hear.

Companies also do not want to hear that their products are assessed according to disputed methods. Yet in LCA, some methodological debates date back nearly as far as the field itself. They defy resolution partly because LCA's models, like those in fields such as climate science and environmental toxicology, are inherently unverifiable (O'Reilly *et al.*, 2011; Oreskes, 1998). In other words, since it is impossible to determine exactly how much the 'life' of a carton of milk contributes to global warming, it is also impossible to prove whether one method of modelling this impact is more accurate than another. Expert consensus is of course still possible, and this was one goal of creating ISO standards for LCA in the late 1990s. But the experts who participated in that process recall that on certain issues they agreed only to disagree. As a result, the standards' language (even after revision in the mid-2000s) is itself ambiguous and open to conflicting interpretations. Initially the conflicts took place mostly in the LCA community's own conferences and journal articles. To the few outsiders who paid attention, they seemed arcane. But as LCA's

prominence has grown, formerly 'academic' disputes have assumed new economic and political significance.

One of the oldest debates in LCA centres on the allocation problem. Some argue that allocation by mass or other physical properties is the most scientific and certain approach. This means, for example, that, if a dairy farm produces twice the milk by weight as it does meat, the milk carries twice the responsibility for the farm's inputs (fuel, feed) and emissions. Others argue that allocation by economic value more accurately reflects this responsibility, since many economic processes occur only because of demand for the most valuable co-products. This is often true of mining: gravel is a common co-product of diamonds and other precious metals, but hardly the reason the mining occurs. Yet another approach to the allocation problem, known as system expansion, essentially assesses the impacts of different co-products' lives in relation to each other. Although the ISO standards recommend this approach, it is less popular partly because it generates greater uncertainties.[12] It is also harder to explain to non-experts.

The ISO standards otherwise offer little guidance on allocation beyond requiring that a study justify its chosen method. While this flexibility suits academic or even internal company research, it does not suit indexes, reporting or labelling schemes that aim to make products comparable. These need firm rules.

In France, arguments about allocation started early on in the government environmental footprint project. In the agro-food working group, producers of *foie gras du canard* parted ways with sellers of its co-product, duck meat. The *foie gras* producers wanted allocation by mass because even the fattest duck liver weighs little compared to a duck carcass. Using this method, their product's carbon and water footprints would appear trivial. The duck meat dealers, on the other hand, wanted allocation by value, because the force-fed ducks are raised for their livers, not their meat. Two years after the working group formed, the government official in charge reported that the *foie gras* dispute was ongoing. 'It's not decided because the reasons aren't technical or objective', he said, 'it's a political choice'.

Another long-running debate concerns whether LCA should describe impacts or predict those resulting from changed demand. The former, traditionally more common approach ('attributional') assumes a steady-state economy and models industry averages. The latter ('consequential') approach tries to take account of market-mediated indirect effects, such as when increased demand for a product leads to a shift in energy sources or production regions. It has fierce advocates, but many LCA practitioners find it difficult to explain, much less apply, in the business context. The two methods sometimes reach dramatically different results, especially when increased demand implies deforestation (as for beef, biofuels and major vegetable oils) (Cederberg *et al.*, 2011; Schmidt & Weidema, 2008). For many large manufacturers and agribusiness firms, in other words, the attributional-versus-consequential debate is not trivial. The relative sustainability of their supply chains and products could look very different depending on the choice of method.

When the 'world's top' LCA experts joined TSC, this was one of the debates they brought with them. Staffers suggest that such debates among the 'academics' slowed progress. But some of the academics are also consultants, and some have stakes in proprietary tools and databases. At TSC they wanted to win not just old arguments, but also new business. At the same time, rival consultants shared a stake in the question of how to adapt LCA to companies' need for fast, cheap product assessments. Too much simplification could threaten the experts' own relevance and the legitimacy of their profession as a whole. Stubborn insistence on complicated methods, however, could do the same. The expert quoted above warned that LCA had to get practical, and do so quickly. Otherwise, he said, Walmart and other big brands would 'move on to other things'. They would find easier ways to measure and demonstrate the sustainability of their goods. And in fact by late 2012 TSC had quietly shifted its focus away from LCA in favour of more synoptic, less quantitative product assessments.[13]

But the problem with LCA is not just that it is complicated. Some critics argue that its perspective on the material world in fact dangerously over-simplifies. This is the weakness that Barry (2002) has identified in metrological regimes more generally. LCA's critics point out that its aggregate, quantitative measures neglect how products' lives matter in particular places and situations, whether for better or worse. Regardless of the accuracy of its data and calculations, such critics argue, LCA's findings amount to little more than a 'house of cards' (ANEC, 2012).

Much of this criticism comes from NGOs concerned about the impacts that LCA captures most poorly, such as toxicity and biodiversity. On toxics, they note that LCA tends to miss chemicals that are potentially dangerous even in minute quantities, such as endocrine disruptors. As one NGO staffer pointed out, a sustainability ranking based on overall impact was not likely to resonate with consumers if a product's small carbon footprint overshadowed its possible health risks. 'Which toy would you rather give your kid', she asked, 'one that has a better [environmental] profile or one that doesn't have chemicals in it that potentially disrupt their development?'

LCA's neglect of the geography and duration of toxic exposure (i.e. occasional versus acute or chronic) also undermines its usefulness for assessing the localized impacts of mining or pesticides. 'You cannot say that a farm worker has the same risk as a consumer of produce; it's night and day differences', said a toxics specialist at the Natural Resources Defense Council. Referring to TSC's work, he added 'a system that does not try to take those differences into account is not going to be credible and will likely greenwash over the real impact, especially for farm workers. And if we do that, it's almost worse than having not having the system at all'.

French officials involved in the environmental footprinting scheme expressed similar concerns about LCA approaches to biodiversity. The law behind the scheme had identified biodiversity protection, especially in the French countryside, as one of the nation's top environmental priorities (Government of

France, 2009). The methods used to assess products' biodiversity impacts were also a top concern for powerful French farmers' organizations. Yet, after a decade's research, LCA methods remain 'in the early stages of development', largely because biodiversity's inherently site-specific nature makes it difficult to quantify, much less model across an entire product life cycle (Curran *et al.*, 2011, p. 71; Geyer *et al.*, 2010).

Initially some French LCA consultancies proposed land use as a rough proxy for biodiversity, meaning the more land used over a product's life, the greater its harm to species and natural habitats. Land-use data are relatively accessible. But this metric would favour the products of intensive agriculture over organic, free-range and artisanal alternatives. It would ignore both on-farm biodiversity and the damaging off-farm impacts of emissions from industrial crop and livestock operations. In short, it was a technically viable proxy, but one that neither producers nor consumers (or for that matter, ecologists) would find credible. French officials involved with the footprinting scheme emphasized that developing a better biodiversity metric was one of their top priorities.[14]

Still, it is not clear whether any quantitative measure could fully capture what biodiversity means 'on the ground', said a Rainforest Alliance representative. Forestry is one of a number of industries (along with agriculture, fisheries and apparel) in which NGOs have played central roles as both standards developers and certifiers. Some have vested interests in these standards, and do not want LCA used in their stead. But NGOs also claim expertise in areas that LCA sees only from afar, if at all. The Rainforest Alliance staffer pointed out that much of what defines a sustainably managed forest – in terms of species composition, disturbance patterns and the benefits to local communities, for example – could be assessed only in the forest itself:

> That's one distinction between LCA and forest certification. LCA is definitely about putting the calipers around something. They're all measurable impacts. Whereas when you go out into a forest . . . there's a lot of judgment involved. Even though you can have a high level of confidence that other reasonable, educated professionals would draw the same conclusions, they're not necessarily in the same category of measurable impacts. They're more nuanced . . . but that doesn't in any way dismiss the realness of those impacts. I'm not suggesting they're fluffy or anything. They're very real and tangible. They're just tough to put a caliper around.

A consultant who works with the Sierra Club put the problem more bluntly: 'LCA doesn't get into the site-specific impacts of crappy forestry'. He suspected that the 'status quo forest products industry' likes the technique for this very reason, and noted that some companies already used LCA to claim that wood in general, regardless of origins, was an overall greener building material than steel or concrete.[15] Even if technically true, he said, such claims threatened to undermine NGO efforts to set higher standards.

Especially in the US, relatively few environmental NGOs know enough about LCA to judge its potential implications for their own standards or advocacy concerns. The opinions voiced here therefore do not necessarily represent a broader NGO view. For their part, some LCA practitioners dismiss NGOs as 'not interested in the facts'. They say that NGOs have no use for a big picture perspective if it neglects their particular cause or locality. But no initiative to use LCA's metrics to define sustainability can afford to ignore NGO criticism. After all, NGOs' past accusations of greenwashing, and the resulting consumer confusion, count among the reasons why high-profile companies turned to LCA in the first place. They wanted its 'holistic' and science-based perspective to put such charges to rest.

Conclusions

At international LCA conferences, many of the speakers represent major multinational retailers and manufacturers. Organizers welcome their participation, and see it as evidence of LCA's increasing real-world relevance. The presenters typically report on how LCA has helped their companies 'measure and manage' costs and risks across their supply chains. They describe how they discovered unexpected 'hotspots' and opportunities for efficiency gains, and how the findings help them communicate the importance of sustainability to suppliers, customers, shareholders and top management. Generally they say the expected, given the context. Most striking about these presentations is the concern many reveal about what companies do not know, much less control, about distant supply chain sites. They mention fears of supply scarcities, lawsuits, NGO exposés or major customers (i.e. Walmart) demanding information they do not have. They look to LCA to provide them with the knowledge and authority needed to address these concerns.

These anxieties and hopes may explain more about the current cachet of LCA than anything the technique has yet proven it can do. They also speak to broader tensions endemic to supply chain capitalism. On one hand, companies' increasing governance responsibilities demand new kinds of knowledge (Hughes, 2006; Thrift, 2005). In particular, the rise of 'sustainability' as the overarching ideal of corporate citizenship, combined with growing concerns about the sustained availability of key raw materials, has put a premium on LCA expert knowledge. This is generally not in-depth knowledge about the many realms of environmental and human well-being impacted upon by-products lives. As LCA practitioners themselves point out, they are not field scientists. Rather, their expertise lies in generating the type of information *about* those impacts that companies want: 'science-based', quantitative and seemingly impartial, in the sense of both complete and unbiased.

On the other hand, the very nature of supply chain capitalism complicates the picture. Disarticulated, dynamic and constituted of diverse sites and

relationships, supply chains confound the quest for complete and credible information. LCA practitioners realize that 'complete' is always relative; early in their training they learn that their job is to 'measure what matters'. But supply chain capitalism makes this a quixotic project. It constantly renders data obsolete or unavailable. It constantly invites challenges – from competitors, stakeholders and others – to whatever measures result. For who has the final say on which measures really matter and which can be trusted?

Yet whatever the fate of current initiatives to use LCA to pursue market-driven eco-efficiency, they point to the growing influence of the environmental sciences and related assessment techniques in supply chain governance. This trend aligns with the 'scientism' characterizing neoliberal governance more generally (Hatanaka, 2010; Moore *et al.*, 2011). It also raises questions about the scientific and technical fields involved. How has this influential role – and the opportunities and opposition that accompany it – shaped how the experts themselves produce and assess knowledge? How has it shaped not only the dissemination and effective power of specific findings, but also the experts' perspective on the material world they study? In the case of LCA, the very idea of a product having a cradle-to-grave life – one that can be traced, modelled, visualized and improved – is now widely accepted both by major supply chain actors and those who produce opposing 'stories of stuff'. But this was not always so. Much like the notion of 'the economy' itself, the concept of a product life cycle has its origins in specific calculative practices, developed and carried out by specific types of experts, and in response to specific problems of economic governance. As Mitchell (2005, 2008) shows in his analysis of the early twentieth-century origins of the economy as we know it, the history of such concepts matters not just for understanding the forces and actors that brought them about, but also what they enabled. In its early days, the idea of an ever-expanding economy drew strength from the industrial world's transition from coal to an apparently inexhaustible supply of oil (Mitchell, 2011). This conception of the economy, along with all the models and tools built on top of it, has since underwritten incalculable ecological harm. It is too early to speculate about the broader environmental and social ramifications of LCA's models of the material world. But closer attention is already overdue.

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Notes

1 As Barry notes in his work on 'technological zones', the analysis of metrological regimes is typically 'best conducted in the middle of events . . . when the direction of change is uncertain and contested' (Barry, 2006, p. 244). It is also necessarily multi-sited, and concerned with flows of knowledge between, among others, the metrological experts, their clients and their critics.
2 The journals consulted include, among others, the *International Journal of Life Cycle Assessment*, *Journal of Industrial Ecology* and *Journal of Cleaner Production*. The green business media sources included, among others, Greenbiz.com and Environmental Leader.
3 The historical geography of LCA is important to understanding its epistemic culture, but beyond the scope of this paper. Examples of large companies that use LCA in this fashion include Unilever, Volkswagen, SCA (a Swedish paper and forest products company) and Danisco.
4 http://www.sustainabilityconsortium.org/measurement-science/
5 Social LCA is an emerging but still highly experimental subfield of LCA; see Benoit *et al*. (2010).
6 Most interviewees – including those directly involved in either TSC or the French environmental footprint initiative – expressed similar doubts. Some however anticipated that the next generation of consumers would understand and care more.
7 Tesco cited the high costs and slow pace of carbon footprinting (with each product requiring several months) as primary reasons, along with other retailers' failure to follow its lead. However, a former Tesco employee (and now food industry consultant) described these reasons to me as 'smokescreens' for the real problem, namely 'the customer can't understand the measurement'.
8 Quantis, headquartered in Switzerland with offices in France and North America, grew from 10 to 75 employees between 2008 and 2011. Pre Associates, based in the Netherlands, opened a North American office in 2011 to meet surging demand there. Its main competitor, PE International, reported 33 per cent revenue growth in 2009–10.
9 Intensive livestock production (including dairy and eggs) tends to score better in LCA than organic, free-range or cage-free alternatives, because less land, water and feed goes into each product (Mondelaers *et al*., 2009; Tuomisto *et al*., 2012; Wiedemann & McGahan, 2011).
10 Betz (2011). On the 'hype cycle' see http://www.gartner.com/technology/research/methodologies/hype-cycle.jsp
11 One of these countries is of course China, but the development of a national database of 'fundamental' products is under way there (Wang, 2011). The availability of relevant data is also improving rapidly in Latin America. In sub-Saharan Africa, it remains extremely scarce.
12 For instance, if an orchard produces both grade apples for direct consumption and lower-quality apples for juice, then a system expansion approach would assess the former in light of the latter's function (juice). The question becomes, if this apple juice were not available, what would substitute for it? The 'avoided impacts' of the presumed substitute are then subtracted from those of the eating apples. But determining likely substitutes (orange juice, water, milk?) requires much more market research, and even then the decisions are often arbitrary.
13 Although TSC's website still made repeated references to the benefits of LCA, staff members reported that its focus had shifted towards generating 'category sustainability profiles' (CSP) for broad categories of products (i.e. bedding, coffee, butter). These two-page documents summarize 'the best available, credible and actionable knowledge about the sustainability aspects related to a product over its

entire life'. They draw on published LCA literature, if available, but do not entail original research (see http://www.sustainabilityconsortium.org/smrs-how-it-works/).
14 As of mid-2012, France's Ministry of Sustainable Development had provisionally decided to measure products' biodiversity impacts only at the farm level, rather than across the entire product life cycle. While this metric would take into account more site-specific considerations, some interviewees saw it as less scientific and therefore more likely to be challenged for posing a possible trade barrier.
15 For example: http://www.weyerhaeuser.com/Sustainability/Planet/GreenBuilding.

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