Life Cycle Assessment (LCA) as an introduction to the Circular Economy

The notion of "the circular economy" is gaining increasing traction in some circles. To move towards a circular economy it will be important to better understand the full environmental impacts of products and services, which is what life-cycle assessment (LCA) helps us to do. This paper briefly introduces the circular economy, the concept of LCA, and some practical aspects of LCA.

Słowa kluczowe: sustainability, life-cycle assessment (LCA), packaging

Ocena cyklu życia jako wprowadzenie do gospodarki o obiegu zamkniętym

Pojęcie „gospodarki o obiegu zamkniętym" cieszy się coraz większym zainteresowaniem wielu środowisk. W celu przejścia do gospodarki o obiegu zamkniętym należy lepiej zrozumieć całościowe oddziaływanie produktów i usług na środowisko, co umożliwia narzędzie, jakim jest ocena cyklu życia (LCA). Artykuł skrótowo opisuje gospodarkę o obiegu zamkniętym oraz koncepcję LCA wraz z kilkoma praktycznymi aspektami.

Słowa kluczowe: zrównoważony rozwój, ocena cyklu życia (LCA), opakowanie

Charles J. Corbett, Ph.D.

Professor of Operations Management and Sustainability
UCLA Anderson School of Management
UCLA Institute of the Environment and Sustainability

Sustainability, financial performance, and the importance of measurement

Why should companies care about sustainability? The literature on the link between a firm's environmental and social performance and its financial performance is huge. In the past, firms often thought that environmental or social efforts had to come at the expense of profitability, but practice and research show that that is not necessarily the case. There are many examples of firms that have invested in sustainability-related initiatives that turned out to be profitable. An example of the research is the study by Derwall et al. [1]. No study is definitive, but this particular study does pose some interesting questions. It compares two portfolios of stocks, one with the best environmental performer in each sector and one with the worst, over 1995-2003. The best-in-class portfolio outperforms the worst-in-class one by about 66 percentage points. The two portfolios were assembled using information that was publicly available in 1995, which contradicts conventional theory, by which publicly available information should already be reflected in today's stock prices. The authors are cautious in drawing conclusions, but they suggest that this does raise an "eco-efficiency premium puzzle": why did the stock market not realize that the more environmental firms would perform better over time?

One answer is that investments in sustainability often have benefits that are only apparent after the fact. There are endless illustrations of this. A well-known one is Walmart's experience[1]: after launching their major sustainability initiative in 2005, in May 2006 they installed auxiliary power units (APUs) in trucks to allow drivers to turn off the engines and use the APU for heating and cooling and power-

There are many examples of firms that have invested in sustainability-related initiatives that turned out to be profitable

ing communication systems. That could eliminate 100,000 tons of CO_2 emissions per year while saving Walmart $25 million per year. What is interesting about examples like this is that the firms in question had not seen this profitable opportunity until they started looking through the lens of sustainability. If even a famously cost-focused company like Walmart discovers previously unrecognized opportunities for cost savings by taking an environmental perspective, one can only imagine the opportunities at other firms. Once a firm starts measuring its environmental (or social) impacts, it is likely to find opportunities for improvement. However, by definition, it cannot predict those opportunities until it actually starts measuring. This may help explain the "eco-efficiency premium puzzle", and is one reason why tools such as LCA can be valuable. Investors are beginning to pay more attention to sustainability, as demonstrated by the success of organizations such as CDP (formerly the Carbon Disclosure Project), GRI (the Global Reporting Initiative), and SASB (the Sustainability Accounting Standards Board), each of which is focused on some aspect of improving firms' communication about their environmental and social performance.

The circular economy

Now that sustainability is increasingly established as a core concern in many firms and governments, a further evolution emerging in some corners, including the EU, is a focus on "the circular economy". The Ellen MacArthur Foundation is a key proponent of the circular economy, and its website[2] provides much more detail, including several comprehensive reports prepared in collaboration with McKinsey and others. It seems immediately clear that "the circular economy" must be closely linked to reverse logistics. The concept includes the following five principles [2, p. 22]:

- Design out waste.
- Build resilience through diversity.
- Rely on energy from renewable sources.
- Think in 'systems'.
- Waste is food.

The discussion of the circular economy frequently refers to the notion of "life cycles", which means it is important to better understand the full life cycles of today's products and services.

Life-cycle assessment (LCA)

Guinée et al. [4] and Guinée and Heijungs [5] provide an excellent introduction to LCA. They use the definition from ISO [6]: "LCA offers a method for quantitatively compiling and evaluating the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle. LCA consists of several steps:

- First, the goal and scope of the analysis must be defined. One can never assess all environmental aspects of a product or service, so a boundary that is appropriate given the goal of the study must be chosen. That boundary may vary depending on whether the goal is to compare two products, two potential vendors, to choose between competing policy proposals, etc.

- Second, during the inventory analysis, the actual impacts are measured. This can be done using bottom-up methods, starting from detailed diagrams of the process in question, or using top-down methods, using aggregate economy-wide estimates of the environmental impacts associated with the products and materials in question. Bottom-up methods are more precise but can be very cumbersome, while top-down methods can be quick but may or may not be accurate enough. Hybrid methods are emerging to combine the best of both approaches.

- Third is the impact assessment, which involves the conversion of the results of the inventory step into categories of impact, such as climate change or toxicity.

- Finally comes the interpretation of the results.

A classic example of LCA is drying hands: should one use paper towels, cotton roll towels, a traditional hands-under dryer, or a newer high-speed hands-under or hands-in dryer? Gregory et al. [3] show that, in terms of global warming potential, the high-speed hands-in dryer is the best option, with the traditional hands-under dryer performing worst. Clearly, such comparisons are heavily dependent on many assumptions, such as how many paper towels each person uses, and how long they keep their hands under the dryer. Gregory et al. [3] include a nice illustration of how to incorporate uncertainty, showing that the high-speed hands-under dryer is still the best option in a wide range of cases.

Another good example of LCA, in the packaging sector, is the comparison of three types of tuna packaging (can, retort pouch, retort cup), by Poovarodom et al. [9]. The tuna meat itself is the largest contributor to greenhouse gas emissions. Specific to the packaging, the material in the can has higher emissions than the other two options, but the retort pouch and cup have higher processing-related emissions, largely due to sterilization.

Both of these examples focus only on greenhouse gas emissions; a full LCA would include a much wider range of impacts, including ozone layer depletion, acidification, human toxicity, eco-toxicity, land use, water use, and more. A well-known example of how different metrics can lead to different preferences comes from a relatively early LCA of automobiles, by MacLean and Lave [8]. When focusing on energy, the use phase is the dominant part of the life cycle; on the other hand, toxic releases are higher

during the manufacturing phase. A recent study by Speck et al. [10] shows that the choice of which LCA software can make a difference. They compared aluminium cans, PET bottles, glass bottles, aseptic carton, and PLA bottles, using two widely-used LCA packages (SimaPro and GaBi). For greenhouse gas emissions, both packages led to similar rankings of the packaging options (with glass bottles having highest emissions, and aseptic carton the lowest). However, for water depletion and consumption, the findings were not consistent, with aluminium cans having the lowest impacts using SimaPro but the highest using GaBi. This points to the need to conduct LCAs carefully, and to document the process well, including the assumptions made and the data and software used.

One might be concerned that LCA is too costly for most firms to use, but two recent studies [7, 11] find that small- and medium-sized enterprises (SMEs) in Poland have had good experiences with LCA: respondents to a survey gave LCA a score of 4.4 out of 5 when asked whether LCA was useful, and 92% said they would possibly or definitely use LCA again. Ongoing developments in the LCA field (see Guinée and Heijungs 2016) are also contributing to making LCA faster, easier and cheaper to use. Although social aspects are not yet easily quantified, there are also efforts underway to formalize the measurement of social impacts of products and services using methods similar to environmental LCA.

Conclusions

As the focus on sustainability in business continues to increase, and with it the interest in moving towards a circular economy, LCA will become an essential tool for many businesses to understand and manage the life-cycle impacts of their products and services, and to make better-informed decisions, taking economic, environmental and social considerations into account. ■

REFERENCES:
1. Derwall J., Guenster N., Bauer R., Koedijk K., *The Eco-Efficiency Premium Puzzle*, "Financial Analysts Journal" 2005, 61(2), pp 51-63.
2. Ellen MacArthur Foundation, *Towards the Circular Economy 1: Economic and Business Rationale for an Accelerated Transition*. Available at www.ellenmacarthurfoundation.org/business/reports/ce2012#, 2013, (16.06.2015).
3. Gregory J.R., Montalbo T.M., Kirchain R.E., *Analyzing uncertainty in a comparative life cycle assessment of hand drying systems*, "International Journal of Life Cycle Assessment" 2013, 18, pp. 1605-1617.
4. Guinée J., Heijungs R., Huppes G., Zamagni A., Masoni P., Buonamici R., Ekvall T., Rydberg T., *Life Cycle Assessment: Past, Present, and Future*, "Environmental Science & Technology" 2011, 45(1), pp 90-96.
5. Guinée J. and Heijungs R., *Introduction to Life Cycle Assessment, In: Sustainable Supply Chains*, Y. Bouchery, C.J. Corbett, J. Fransoo and T. Tan (eds.), Springer 2016; in preparation.
6. ISO International Standard 14040, *Environmental management - Life cycle assessment - Principles and framework*, International Organisation for Standardisation (ISO), Geneva 1996.
7. Kurczewski P., *Life cycle thinking in small and medium enterprises: the results of research on the implementation of life cycle tools in Polish SMEs—part 1: background and framework*, "International Journal of Life Cycle Assessment" 2014, 19, pp 593-600.
8. MacLean H.L., Lave L.B., *A Life-Cycle Model of an Automobile*, "Environmental Science & Technology" 1998, 3(7) 322A-330A.
9. Poovarodom N., Ponnak C., Manatphrom N., *Comparative Carbon Footprint of Packaging Systems for Tuna Products*, "Packaging Technology and Science" 2012, 25, pp 249-257.
10. Speck R., Selke S., Auras R., Fitzsimmons J., *Choice of Life Cycle Assessment Software Can Impact Packaging System Decisions*, "Packaging Technology and Science" 2015, 28, pp 579-588.
11. Witczak J., Kasprzak J., Klos Z., Kurczewski P., Lewandowska A., Lewicki R., *Life cycle thinking in small and medium enterprises: the results of research on the implementation of life cycle tools in Polish SMEs—part 2: LCA related aspects*, "International Journal of Life Cycle Assessment" 2014, 19, pp 891-900.

FOOTNOTES:
[1] Source: "Wal-Mart is Taking the Lead on Environmental Sustainability", Wal-Mart internal memo, 2008.
[2] See www.ellenmacarthurfoundation.org/circular-economy, (16.06.2015).

This paper follows the invited keynote presentation that the author delivered at the V International Conference on Reverse Logistics in Wroclaw, June 16, 2015.