

EVALUATING A SUPPLY CHAIN'S CARBON FOOTPRINT – A METHODOLOGY AND CASE EXAMPLE OF CARBON-TO-SERVE

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Abstract

The world is now sensitised to global warming and the effect of carbon emissions. The national targets are to reduce emissions by 60% by 2050. Business and political leaders talk about 'Plan A because there is no Plan B'. But the unanswered question is 'What is Plan A?'.

To answer this question, there is a requirement to be able to generate a reliable estimate of the carbon intensity of different chains and to be able to model the potential for different scenarios – covering materials, conversion and transportation. This paper describes a methodology for estimating and visualising the carbon intensity of products as they move from source to consumption. The approach presented builds on a supply chain mapping technique called Time-to-Serve and a modelling project completed at Cranfield in 2007 on the carbon transportation impacts of global sourcing. A case study applying the methodology is provided showing how the methodology and model can be applied to test options and predict the impacts of change. In the context of the targets that have been set, the widespread application of this kind of methodology will be essential to support policy making and future supply chain design.

Keywords: environment, carbon emissions, supply chain, supply chain mapping, supply chain design, modelling

SECTION 1 - Introduction

The environmental impact of energy consumption by the global economy has attracted increasing commentary over the last 5 years. The scale of the public interest is remarkable and can be illustrated by the following statistics: in one hour 25 articles were published on Google News: in one day 199 articles were published: in one 1 week 1,734 were published. If you "Google" global warming over 60million references are returned. The predictions for global warming leave London under water, grapes grown for wine in the UK's midlands and the demise of entire species.

The UK Government has established an Office for Climate Change and has committed to lowering emissions by 60% by the year 2050. The term carbon footprint has become a commonplace expression of the need to be concerned about personal and corporate energy use and the environmental impacts of both production and consumption. Software vendors have got involved in the process of helping companies evaluate their emissions as part of their accounting systems, or model the carbon implications of their transport networks.

The context of this paper has been well established through the science of global warming and predictions of the detailed effect of climate change effects. The seminal work titled 'An inconvenient truth' (Gore) is widely attributed with having raised the perception of global energy consumption and its impact on the eco-system to the point where it can no longer be denied. Through the associated film, it has reached and touched the perceptions of many in the political arena. Doubtters and naysayers remain but they are now in the minority.

However, the world is addicted to its current pattern of consumption (Hari) and the political will to make changes is only gathering pace with a few major economies, notably the USA and China, unwilling to adopt radical policies for change (Financial Times). Although recently in the US both Obama and McCain have spoken in favour of the need for ambitious emissions reductions. Whilst Kyoto protocol has stalled as a process for global action on sources of emissions, and must be revived in 2009, the consensus is that this is a global problem. It is acknowledged that emissions impact the eco-system without economic or geographical discrimination.

It appears that consumers are more prepared to make changes than their leaders and many companies have moved to exploit this with 'green' products and services. Retailers have started to market aggressively their environmental credentials and, for example, taken publicity grabbing measures on plastic bags by introducing charges and encouraging recycling.

This paper describes a methodology and model for mapping the carbon effects of end-to-end supply chains and evaluating alternative designs and specifications. It is based on established supply chain mapping methods and the aim has been to provide a transparent approach to the problem. Section two provides a brief reminder of some key references in the literature. Section three provides observations on carbon reduction programmes. Section four introduces the innovative idea of supply chain carbon mapping as a way to visualise the issues and potential for change. Section five describes the model and provides some initial output on the implications for change in the wine industry. Section six details the requirements for further work to establish this approach as a standard.

SECTION 2 - Literature Review

The literature is crowded with commentary and analysis on the science, social and economic impacts of climate change, as described in the introduction. This paper is not a review of that work and starts from the position that this is a pressing threat to 21st century way of life. A Financial Times survey of the June 3, 2008 pulls together work from leading contributors (Financial Times). Gore's work is credited with changing perceptions of the issues for ever (Gore). The British Government commissioned Stern to review the economic impact of climate change (Stern) and he concluded that sustainability was still a practical goal. He reported that the choice between being 'rich and dirty' or 'clean and green' was avoidable; we can be 'green and rich enough'. The practicalities of responding to the sustainability agenda in the UK has cascaded out from the newly formed Office of Climate Change, to individual ministries with specific responsibilities for energy, transportation and the environment, inter alia. The goals for carbon reduction have been set at 60% by 2050, with transport contributing 36% of national carbon emissions. The Department for Transport commissioned an independent review (Eddington) of transport policy and has since published a discussion paper 'Towards a sustainable transport system' which outlines the options for change and starts to set a policy making framework (DfT).

All of these references are macro in nature and do not contribute to the detail of what needs to change in order to enable the goals to be met. Efforts in this respect are founded in parallel approaches: measurement and modelling. The Carbon Trust has been established as an independent government funded organisation to work with companies to reduce their emissions (Carbon Trust). It has established measurement and labelling of the carbon impact of products as a major initiative. This has been recognised by retailers who have adopted the

standard and in the case of TESCO gone further. Sir Terry Leahy in a speech in January 2007 said:

- “I can announce this evening that Tesco will take the first step towards developing this - by commissioning work from the Environmental Change Institute (ECI) at Oxford University, on identifying and overcoming the carbon pressure points in our own operations and supply chain. This work can best be done in collaboration with our world-class suppliers and distributors, and our retail colleagues. We have already begun to work with Unilever and are looking to collaborate with many others around the world. To create a mass movement in green consumption we must provide better information. Clear information about the carbon cost of the products we buy will enable customers to make effective green choices. Customers want us to develop ways to take complicated carbon calculations and present them simply. We will therefore begin the search for a universally accepted and commonly understood measure of the carbon footprint of every product we sell – looking at its complete lifecycle from production, through distribution to consumption. If we are to tell our customers the carbon cost of every product, we owe it to them too to minimise that cost.” (Leahy)

As Leahy said: “the search is on”. Work by Cranfield with the DfT modelled the carbon impacts of international supply chains to establish the relativity of different routes and methods of transport on the cost and carbon of the total supply chain. (Christopher et al.). It became clear from this work that the emissions in production (wherever that is in the world) are a much more significant contributor to the total carbon impact of a product than its distribution. The modelling method developed and published in that research has been the technical foundation for the work described in this paper.

Two final themes have been seminal in the development of this work: supply chain mapping and the Laws of Logistics and Supply Chain Management. Supply chain mapping has been identified as a critical skill in their redesign to increase effectiveness. (Hines)(Christopher). The ability to visualise a chain and, from that map, discuss the implications of doing things differently is a valuable way to consider changes. Supply cost management, that evaluates the cost build up of the end-to-end chain, supports the insights of supply chain mapping by pointing to where costs are excessive, their drivers and the opportunities to improve performance. This Cost-to-Serve method is now well established as part of the supply chain redesign toolbox. (Braithwaite) The fundamental concept sitting behind Cost-to-Serve is the second ‘Law of Supply Chain Management’ – the Law of Lowest Total Cost. (Braithwaite and Wilding). It states simply that the cost of chain is not optimised by adding the lowest possible costs of each of the functions; we expect the same to apply to carbon emissions. A balancing process is required along the end-to-end chain.

This short literature summary points to the need for tools and techniques to support the re-balancing of end-to-end supply chains and shows the provenance of the idea of adapting mapping and cost-to-serve methods to create a carbon-to-serve methodology.

SECTION 3 - Observations on Carbon reduction programmes and gaps in the literature

The most widely publicised measurement of a total supply chain’s carbon impact is that of Walkers Crisps by the Carbon Trust. As a result of this work, we are informed that a packet of crisps weighing 35 grams has generated 75 grams of CO₂ in its journey from field to shelf, where it puts just 22.5 grams of carbohydrate into the human frame. Put in that way, it does not seem good value and the key questions are: ‘how could it be different?’ and ‘are crisps a doomed product?’ The published material on this case points to improvements arising from reducing the water content of the potatoes to saving freight tonnage as being one of the biggest ideas. At no point in the literature and publicity material does it clearly state how that relates to the total emissions for the product and what radical change could be made that would support the national targets. The likely reason for this omission is firstly that it will have been rather

small and secondly that radical change would reduce competitiveness and be 'unacceptable' in marketing terms.

As this area matures, the analysis needs to be more transparent than that apparently offered by the Carbon Trust to facilitate discussion of improvements. The experience of the authors is that there are many data sources on carbon emissions with a significant lack of expert agreement on the true emissions for different elements of the chain. The fact that the experts do not agree and that there is no standard library of emissions rates is a concern as it allows doubters to question the outputs of any analysis. However, it also points to the fact that there are considerable local differences which may allow an organisation to select one figure or another. For example, most recently emissions for sea freight have been brought into question in terms of its previous claims to be environmentally friendly and this has highlighted the wide variations in sea freight efficiency.

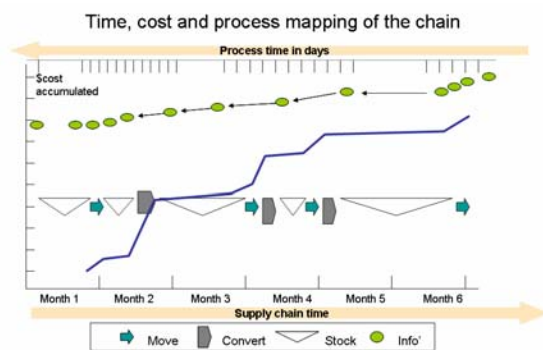
The gap in carbon measurement and reporting appears to be the lack of transparency of measurement and measures so that organisations and consumers can draw their own conclusions and plan step changes in the way they do business – even if the data is not perfect. It is this gap that the work in this paper has tried to start to fill.

SECTION 4 - Supply Chain mapping as a way to visualise issues and potential for change

The work of Hines, discussed earlier, creates a complete landscape of supply chain mapping approaches with their respective provenances. Braithwaite, with LCP Consulting, has combined a number of techniques into a methodology that hitherto has been unpublished. The approach is illustrated in concept in Figure 1 titled 'A composite approach to mapping supply chains'.

On the left of this diagram is the conceptual model; on the right is an actual chain. The starting point for this approach is that it should cover the end-to-end chain extending from customers back to suppliers where appropriate. The second key principle is that supply chains are fundamentally simple and contain only three types of activity: inventory, movement and conversion. All chains can be broken down into their unique DNA sequence of these events which may involve, within just one function, all three types of event. For example, in a plant or warehouse there may be inventory in more than one location and several internal processing and transportation events. The first step in mapping a chain is to draw out the chain scaled to time along the bottom axis and representing each of the three types of event in their sequence of occurrence. On the left this is represented in standard convention of an inverted triangle for inventory, a block arrow for conversion and an arrow for transport. On the right side, in the case example, the convention has changed to colour coded diamonds to support ease of production. Also, the scale is non-linear to compress the diagram from its 140 days to a chart that can be viewed on a single page. A scaled map could be measured at more than 10 metres, so a level of pragmatism is required in the way in which the chart is prepared.

Onto this chart format are added two additional important pieces of information. The first is the accumulation of cost which is the line moving upwards from left to right on the model concept and the grey shaded area in the case. This shows how cost builds through the chain and makes it immediately obvious where the dominant supply chain cost issues are in relation to time in the chain. The second is to add at the top the sequence of processes that are driving the conversions, inventory and movements. This is usually drawn on a broken scale and can be in tiers to reflect the different process ownership and business systems that are in place.



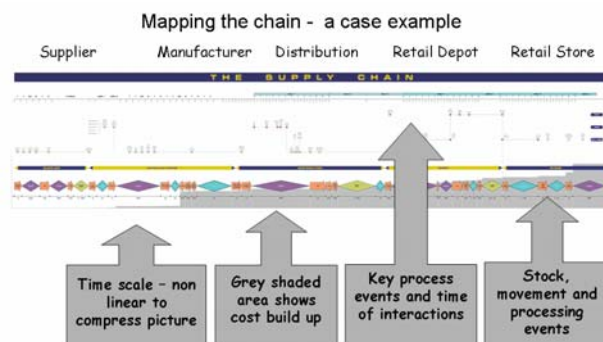


Figure 1 – A composite approach to mapping supply chains

Bringing this end-to-end picture together enables a discussion between functional owners on how cost and performance is impacted up and down the chain by the processes. The experience of such discussions is that they generate the most challenging questions about the design and execution of the supply chain. This approach often leads to the identification of substantial improvements. The case example on the right of figure 1 was a joint project between Sainsbury and SCJohnson Wax completed by LCP Consulting. The value of the approach was confirmed in a conference presentation on the Oriana in 1999 and through a review by a team from Templeton College Oxford. This and many subsequent projects undertaken by LCP Consulting have never previously been academically documented for reasons of commercial confidentiality.

SECTION 5 - The Carbon-to-Serve model and the Initial outputs

The carbon-to-serve model and methodology is a logical development of the time-to-serve and cost-to-serve approach described in the previous section. The carbon emissions build up replaces the cost build up and there is no requirement for the process elements to be included. The concept remains unchanged, with one exception, which is the way in which the model must be able to capture raw data on every activity in the chain and normalise it to the carbon [CO₂] per unit of output/consumption. The opportunity has also been taken to improve the modelling technique using the learning from the Cranfield Global Sourcing Model, providing some automation of graphical representation of the chains and their carbon impact.

The working prototype model has been developed based on the Australian Wine Industry. This is an industry that has grown its sales rapidly in the UK but is now facing simultaneous declines in consumption and global over-production. The consequential pressures on price and cost at the volume end of the market are forcing many options to be considered for the supply chain. At present wine is bottled in Australia and shipped in containers to the UK, either directly to retailers or to a distribution centre for subsequent picking and dispatch to retailer distribution centres. Some options for the future include: shipping in bulk and bottling in the UK; shipping a higher proportion directly to retailers; and changing the packaging to reduce cost and carbon content. It will be important to understand the relative impacts of such scenarios as well as others that may arise.

The model to achieve this is constructed in Microsoft Excel and is built in three steps. Step one is to construct the best possible picture of the supply chain on a time base. There is an important development from the mapping approach described in the previous section in Figure 1. The supply chain needs to be represented as parallel supply side tracks that combine at different points in the chain; this enables all the associated activities of packaging, and production to be represented. The results of this change with some visualisation alterations to facilitate the use of Excel are shown in Figure 2. It shows the end-to-end chain for wine from Vineyard to store shelf and includes the field operations such as the consumption of fertilizer and the supply of bottles and packaging. All of these events contribute to the carbon build of the

chain and must therefore be included in the model. The map suggests that the end-to-end wine chain can be as much as 52 weeks long

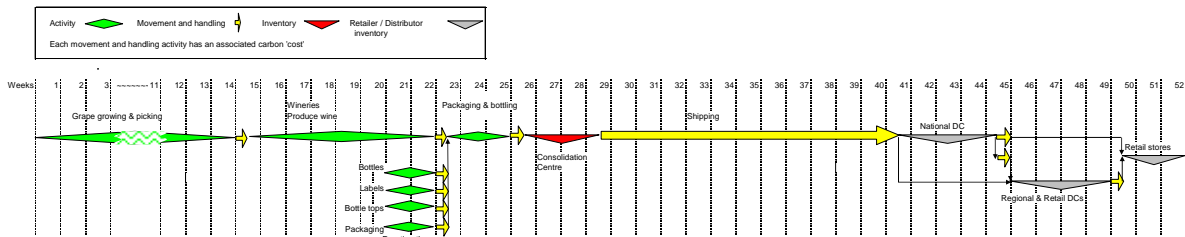


Figure 2 – the wine supply chain map

Step 2 is to extract and normalise the data on energy consumption and emission. This is important because the ratios of usage and coverage vary for the activities along the chain. The application of fertilizer is measured on tonnes per hectare or similar. A tonne of fertilizer will have a basic measure of energy use for its manufacture and distribution. A hectare of vines will produce a standard measure of tonnes of grapes which in turn generates litres of wine. The process of normalisation is the calculation to bring all of the supply chain components back from their standard local measure to the equivalent carbon to produce, in this case, 1000 litres of wine. Similarly a tonne of glass consumes energy in its creation and that tonne converts into a number of bottles. With each bottle containing 75 cl, we are interested in the tonnes of glass to create 1,333.33 bottles which will hold 1000 litres.

The normalization process is built into the model and in this case is specific to growing of grapes through to the fermenting, bottling and distribution of wine. We have concluded that, once conceptualized and modelled it is easy to adapt to other industries subject to the data being available.

Step 3 is the mapping of the carbon-to-serve of the chain which the model does automatically based on the time taken for the process and the progressive summation of the elements of the chain normalised to the 1000 litre standard. The model automatically draws the carbon build up as the grey shaded area on the time scales for the chain as shown in Figure 3. This example is not a validated one for the wine industry.

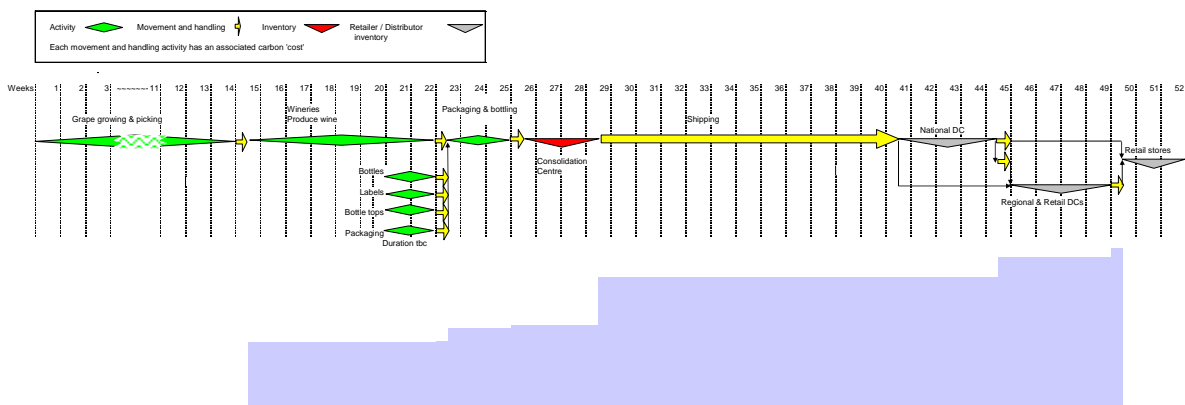


Figure 3 – A carbon-to-serve map for the wine supply chain

The principle value of this work is that it can be repeated quickly for different scenarios to show their reduction potential and it can be aligned to the cost-to-serve to enable business decision making. However, as the world gets used to the carbon issue, it can form a basis for refinement of the inputs and discussion of the conclusions between the parties in the supply chain. Supply chain re-design will depend on the parties in the chain viewing the same consistent information (even when not perfectly accurate) and using it as a platform for discussion.

SECTION 6 - Further work

The modelling approach described is a prototype form and has yet to be fully applied on the case described. Experience will be gained from that application and the approach will evolve as a result. At this time, we have identified that further work is required to refine the model and ensure that it delivers robust guidance on the areas of carbon reduction potential and the relativity of the choices available. This work will need to concentrate on three areas.

First there is a requirement to access and catalogue reliable carbon emissions data for the different activities that make up this chain and the many others that will need to be modelled. Second, the model should be refined to incorporate supply chain cost alongside the carbon assessment; this will support the discussion and decision making process about where the business might carry higher cost to reduce carbon substantially. Third, the modelling should be developed and enhanced to allow the creation and retention of scenarios, allowing comparison and hence supporting decision making.

Of these three developments, the first presents the greatest challenge. Securing and cataloguing reliable carbon emissions metrics as they relate to all aspects of production and distribution is a challenge as there are so many dimensions to every measure. Production in different countries in Europe and Asia will carry different metrics; for example the attributes of power generation vary according to whether it is nuclear or conventional and the efficiency of the generators in the different countries. The environmental efficiency of plants for energy consuming products like glass or steel may also vary enormously. Metrics for suppliers and suppliers' suppliers may be difficult to obtain. Finally, even the measures for well established activities like transportation may be the subject of detailed technical debate.

The view of the authors is that the issues over data should not be a barrier to application of the methodology. The approach is designed to support refinement over time and many of the numbers will not have a significant impact on the overall conclusion. The importance of cataloguing and documenting the variations and their underlying conditions should be a priority for academics and interested organisations. This will provide the improved transparency which carbon foot-printing needs.

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