Institution: Lancaster University

Unit of Assessment: 7, Earth Systems and Environmental Sciences

Title of case study: Practical carbon metrics to quantify and aid reductions in greenhouse gas emissions by corporations, to inform legislation and to engage the public.

Period when the underpinning research was undertaken: August 2007 – November 2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Prof. Nick Hewitt	Distinguished Professor of Atmospheric Chemistry	01/08/1985 to present
Prof. Mike Berners-Lee	Professor of Sustainability	01/03/2016 to present
Dr Kim Kaivanto	Senior Lecturer in Economics	13/10/2003 to present

Period when the claimed impact occurred: August 2013 to November 2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact

Lancaster researchers have developed a research-based environmentally extended input-output (EEIO) model for quantifying greenhouse gas (GHG) emissions resulting from economic activities. This has allowed them to have significant impact in three areas: (1) on UK policy and legislation related to reporting GHG emissions. Specifically, UK policy on GHG emissions reporting was influenced by their submissions to the House of Commons Energy and Climate Change Committee; (2) on GHG emissions and target-setting by corporations. Specifically, the researchers have used the EEIO model developed in their underpinning research to help more than 70 organisations (ranging from multinationals and large public bodies to local businesses) to quantify the GHGs embodied in their upstream Scope 3 GHG emissions (i.e. the indirect emissions in their business supply chains). In some high-profile examples, organisations have used the Lancaster model to set formal targets for reducing their Scope 3 GHG emissions. Notably, BT and Microsoft (with a combined turnover of GBP120 billion y^{-1}) have committed to reduce their Scope 3 emissions by 29% and 30% respectively by 2030; (3) on the public understanding of GHG emissions. Lancaster research has provided the basis for three popular science books (more than 100,000 books sold as of November 2020), approximately 100 radio and TV appearances, including on 'Climate Change - The Facts' presented by Sir David Attenborough on BBC One TV (16.6 million viewers), and more than 100 community and educational events. All these activities contributed to an increased public literacy around climate change.

2. Underpinning research

The researchers' work in this area began with [3.1] which updated, developed and extended a pre-existing model for carbon accounting (the process by which organisations quantify their GHG emissions). This model was applied to bilateral UK-China trade. To support this applied work, [3.2] showed theoretically that decarbonisation, not just efficiency gains in energy use, is required to reduce global GHG emissions. In parallel, the researchers developed their own more rigorous GHG emissions model that allows organisations of any size and type to quantify and attribute their supply chain GHG emissions, to set verifiable emissions targets, and to understand the effects of interventions on their supply-chain emissions. Papers [3.3] and [3.4] describe the development, testing and validation of this model. Papers [3.5] and [3.6] provide examples of specific applications of the model to understanding the climate change impacts of food and diet for businesses, individuals and other organisations. The underpinning research therefore has three areas of focus:

a) A new environmentally-extended input-output (EEIO) model for GHG accounting [3.1, 3.3 and 3.4]

This applied research has focused on delivering meaningful supply chain GHG emissions information for organisations of all sizes to inform management decision-making. Paper [3.1] developed and used a first-generation EEIO model to show that the production of goods in China for export to the UK in 2004 saved the UK potential emissions of 69 Mt CO_2e (CO_2e being carbon dioxide equivalent), relative to the production of the same goods in the UK but resulted in additional emissions of 186 Mt CO_2e in China.

Paper [3.3] describes the development and use of Lancaster's much more rigorous EEIO model, which draws upon both fine-grained national input-output data and process-based life cycle analysis techniques. This hybrid model superseded that used in [3.1] and allows the GHG emissions embodied in an organisation's activities and supply chains to be quantified by combining incomplete but specific estimates generated by life cycle analysis with the comprehensive but generic estimates made available through EEIO. It can be used with organisations of any size or sector and its scalability, robustness and practicality make it a unique business tool, hence its successful application to so many diverse organisations (see section 4).

Paper [3.4] presents a robust validation of this hybrid model for supply-chain carbon accounting by making a detailed comparison between it and various other published input-output and process-based models. The results showed that the carbon accounting accuracy of the hybrid model is affected by the detail of the methodological decisions used, including: the economic region or regions upon which the model is based; the quality, disaggregation and temporal alignment of data, especially for price-volatile products; the various ways of treating gross fixed-capital formation; and the enhanced effects of GHG emissions from aircraft at high altitude.

(b) The importance of decarbonisation of energy supplies [3.2]

The theoretical work [3.2] demonstrates that energy efficiency gains are not in themselves sufficient for reducing GHG emissions in a growing global economy and that decarbonisation of global energy supplies is necessary to avoid rebounds in emissions. This discovery has fed into the researchers' applied work on reducing GHG emissions by organisations and underpins the advice given to organisations (e.g. to BT), following application of the hybrid model, to seek alternative zero- or low-carbon energy supplies and not just energy efficiency gains.

c) Application of the Lancaster model to greenhouse gas emissions from food [3.5 and 3.6]

Integration of the Lancaster carbon-accounting model into a wider carbon toolset enabled studies on the greenhouse gas impacts of food and dietary choices. Paper [3.5] applied the EEIO model and other analyses to the sales of a supermarket chain, combining data on food purchased and wasted with the embodied GHG intensities of food types and product lines at a fine scale. The researchers calculated that the current average population-weighted diet in the UK has a GHG footprint of 2.7 t CO_2e y^{-1}, representing 19% of total UK emissions. We showed that GHG savings of 22% and 26% are made by changing from a typical diet to a vegetarian or vegan diet respectively. In [3.6] the researchers went further and showed how realistic consumer choices over diet and food wastage can result in significant and achievable reductions in GHG emissions at scale. For example, dietary change from GHG-intensive meat (e.g. beef) to less GHG-intensive meat (e.g. chicken) can reduce food-related GHG emissions by 18% and eliminating avoidable food waste can reduce food-related emissions by 12%. To aid public understanding of the magnitude of these potential GHG savings the researchers compared them with population-average road vehicle emissions of GHGs.

3. References to the research

[3.1] You, L. and Hewitt, C.N. (2008) The effect of trade between China and the UK on national and global carbon dioxide emissions. *Energy Policy.* 1907-914. (307 citations, Google Scholar)

[3.2] Jarvis, A., Leedal, D., and Hewitt. C. N. (2012) Climate–society Feedbacks and the Avoidance of Dangerous Climate Change. *Nature Climate Change.* 668-671. (46 citations,

Google Scholar) In the top 5% of all research outputs scored by Altmetric with a score of 30 as of 26th November 2020). A public lecture summarising [3.2] is available on You Tube (382 hits)

[3.3] Berners-Lee, M., Howard, D., Moss, J., Kaivanto, K., and Scott, W. (2011) Greenhouse gas footprinting for small businesses - The use of input-output data. *Science of the Total Environment*. 409, 883-891. (105 citations, Google Scholar)

[3.4] Kennelly, C., Berners-Lee, M., and Hewitt, C.N. (2019) Hybrid life-cycle assessment for robust, best-practice carbon accounting. *Journal of Cleaner Production 208*, 35–43. (9 citations, Google Scholar)

[3.5] Berners-Lee, M., Hoolohan, C., Cammack, H., and Hewitt, C.N (2012). The relative greenhouse gas impacts of realistic dietary choices. *Energy Policy*. 43, 184-190. (325 citations, Google Scholar, Altmetrics score of 115)

[3.6] Hoolohan, C., Berners-Lee, M., McKinstry-West, J., and Hewitt, C. N. (2013) Mitigating the greenhouse gas emissions embodied in food through realistic consumer choices. *Energy Policy* 63, 1065–1074. (153 citations, Google Scholar. Altmetrics score of 83 and cited in three policy papers: The FAO-IPCC Expert meeting on climate change, land use and food security (2017), EU Publications Office report "Energy Use in the EU Food Sector: State of Play and Opportunities for Improvement (2015), and the National Institute for Public Heath in the Netherlands "The environmental sustainability of the Dutch diet" (2017).

4. Details of the impact

Impact on UK Policy and Legislation: The UK Government enacted legislation on the 1st October 2013 requiring mandatory reporting of GHG emissions by the UK's largest quoted companies (Statutory Instrument 2013/1970:5) [5.1]. This followed the presentation of written and verbal evidence by Hewitt and Berners-Lee to the House of Commons Energy and Climate Change Committee during 2011 to 2012. Paper [3.1] and the results from three case studies (West Sussex County Council, the Lake District National Park Authority and Manchester City Council) which directly used the EEIO model for carbon accounting [3.3] were given in evidence [5.2]. The regional supermarket chain E.H. Booth & Co Ltd gave written evidence to the Committee, based on a report by Berners-Lee [5.3] which used the model and data from [3.5]. In total, 13% of the Committee's 12th Report 'Consumption-Based Emissions Reporting', and most of the policy applications section of the Report, were based on the researchers' evidence (House of Commons, 2012: 14-18) [5.2]. Their submissions were cited in the Report as directly influencing the Committee's recommendation: *"We recommend that the Department of Energy and Climate Change explore the options for incorporating consumption-based emissions data into the policy making process and set out the steps it will take when responding to the Committee's report"* (House of Commons, 2012:(1)35). In 2018, Statutory Instrument SI 2013 was amended to include "*emissions, energy consumption and energy efficiency action by quoted companies*" (SI 2018/1155 Part 6) to reflect the true impact of their operations. This followed a government pledge given in 2013 (Hansard, 2018: 17 Oct vol. 793), resulting from the Energy and Climate Change Committee report [5.2] to which the researchers so significantly contributed.

Corporate Impact: The EEIO model [3.3] has been extensively used by the Lancaster University affiliate company Small World Consulting Ltd. and has been key to the supply chain carbon assessments it has carried out for more than 70 organisations. As well as E.H. Booth and Co Ltd, these organisations include multi-nationals (e.g. BT and Microsoft), large UK-based businesses (e.g. Taylor Wimpey house builders), numerous SMEs, local authorities (e.g. Greater Manchester, Cumbria) and the Lake District and South Downs National Parks. Scope 3 (supply chain) carbon assessments were previously considered to be too complex for operational use by such organisations. The Royal Society recently commissioned work which used the model to help analyse the impact of the use of information technology on climate change.

In the most high-profile examples of the corporate impact of the research, BT (turnover GBP24.0 billion y^{-1}) and Microsoft (turnover GBP96.0 billion y^{-1}) have used Lancaster's EEIO model to set science-based supply chain GHG emissions targets, exceeding their commitments as members of the Science Based Targets Initiative (SBTi). Microsoft and BT have been recognised as the top and 4th–best performing companies for sustainability respectively in the CAC 40, DOW 30, FTSE 100 and IBEX 35 indices [5.5].

Using the model for decision-making and auditing, BT has committed to reducing their *"supply chain GHG emissions by 29% (809 Mt CO2e y-1) by 2030 from a 2016/2017 base-year"*. BT's Annual Report 2019 highlights changes in their practices: "*we reduced our total end-to-end worldwide CO2 equivalent (CO2e) emissions by 7.4%"* during 2018 to 2019, reporting a reduction in Scope 3 emissions of 660 kt CO_2e (2017 to 2019) [5.4]. This target is in line with limiting temperature change to 2°C (Paris Agreement, 2015). Following the IPCC's Special Report on Global Warming of 1.5°C (IPCC, 2018), BT is currently working with the model to evaluate whether to commit to a 1.5°C-compatible target [5.6]. In line with the researchers' advice, based on [3.2], BT now also encourages its customers to switch to renewable electricity.

Microsoft submitted a successful SBTi application, drawing extensively on analysis from Lancaster's EEIO model, with a commitment to *"reduce Scope 3 GHG emissions intensity per unit of revenue by 30% (4.9 Mt CO2e y-1) by 2030 from a 2017 base-year and to avoid growth in absolute Scope 3 emissions*". Microsoft has since gone further, in line with our advice, and has committed to reducing their total emissions including supply chain carbon from 12 Mt CO_2e y^{-1} to net zero by 2030 [5.7].

The Lake District National Park set a carbon budget and using the EEIO model has tracked its GHG emissions for eight years, resulting in more than 0.3 Mt CO_2e savings from local action. This 'Low Carbon Lake District' project formed part of the organisation's successful UNESCO World Heritage Site application (The Partnership Plan, 2015-2020: 89) [5.8].

Public Impact: The researchers have used the EEIO model and the six papers cited here [3.1 to 3.6] to inform the public of their impacts on global GHG emissions via three books (more than 100,000 copies sold) [5.9], online carbon calculators, exhibitions, more than 100 talks and community projects and numerous media appearances [5.10].

Specifically, our EEIO model and [3.3] and [3.4] underpinned the book '*How Bad Are Bananas?'* (2010, updated 2nd ed. 2020), published in English (UK and US markets), Mandarin, Korean and Italian. The book was endorsed by best-selling American-British author Bill Bryson as "*Terrific!…I can't remember the last time I read a book that was more fascinating and useful and enjoyable all at the same time."* 33,859 copies have been sold post-2013 [5.9].

Paper [3.2] underpinned Chapter 1 of *'The Burning Question'* (2013), which was endorsed by Al Gore as *"Fascinating, important and highly recommended"*.

The third book, '*There Is No Planet B'* (2019) draws on all the cited papers [3.1 to 3.6]. It was endorsed by Martin Rees, Astronomer Royal, as *"a lively and cogent assessment of what is happening to the Earth's biosphere and resources"*.

The books received coverage by the BBC, Financial Times, Sun, Telegraph, Guardian, Independent, New Scientist and Nature, among others, with 81 radio and 19 TV appearances by the author, including on the BBC One TV's Climate Change – The Facts (18th April 2019), presented by Sir David Attenborough, which attracted 16.6 million viewers [5.10]. Papers [3.5] and [3.6] informed appearances on Horizon, Panorama and Sky News' '*Living a low carbon life*', together with numerous local engagement activities, including talks to over 100 community groups and schools, where dietary and other lifestyle choices were presented and discussed in the context of GHG emissions and global climate change.

5. Sources to corroborate the impact

[5.1] The Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013 (SI 2013/1970) (Strategic Report Regulations 2013) enacted 1st October 2013 to present.

[5.2] House of Commons Energy and Climate Change Committee (2012) Consumption Based Emissions Reporting. Vols. 1 and 2 (underpinned [5.1])
[5.3] Testimonial from the Chairman, E.H. Booth Ltd. Dated 4th September 2020 and corroborating impact of the research on the supermarket chain.
[5.4] BT Group plc Annual Report (2019) p.26 showing the reduction in their CO2e and Scope 3 emissions.
[5.5] EcoAct (2020) Annual Report: The Sustainability Reporting Performance of the FTSE 100 (pp.6 and 39). Shows Microsoft and BT as the top and 4th best performing companies for sustainability respectively in the CAC 40, DOW 30, FTSE 100 and IBEX 35 indices
[5.6] Testimonial from the Head of Environmental Sustainability, BT Group plc Dated 20th April 2020. Corroborates contribution of the research to BT being a recognised leader in sustainability, and successfully reducing their worldwide end-to-end carbon footprint.
[5.7] Testimonial from the Director of Environmental Product Compliance, Microsoft Corporation. Dated 24th April 2020 and corroborating the impact of the research reducing their Scope 3 GHG emissions and commitment to reduce their total scope 1, 2, and 3 emissions to net zero by 2030.
[5.8] Testimonial from the Chief Executive, Lake District National Park Authority. Dated 20th April 2020 and corroborating the CO_2e savings made.
[5.9] Letters confirming book sales from (a) Cambridge University Press corroborating the sales of '*There is no Planet B'*, dated 23rd November 2020 and (b) Profile Books corroborating the sales of '*How Bad are Bananas?*' and '*The Burning Question'*, dated 11th November 2020.
[5.10] Public reach report incorporating media appearances, including Prof. Berners-Lee speaking on BBC One's 'Climate Change – The Facts', (2019) presented by Sir David Attenborough.