DAVID & CHARLES
PUBLISHING

Sustainability review and action plan

March 2024

Contents

Opening message

There is little need to introduce the context for this document and its importance. Since our management buy-out in 2019, the Directors at David and Charles made a commitment to 'do the right thing' across our business, and our sustainability practices are at the forefront of that thinking.

Our early stages in this process included an immediate move to printing on FSC paper, and the appointment of an internal sustainability 'Guardian' to be the voice of this important issue across our business decisions.

We have now taken some significant leaps forward in our understanding of this issue, helped by ever more readily available tools within the industry. We therefore feel confident for the first time to publish this review and action plan document.

What this document represents

This review document is not perfect or entirely comprehensive. There are gaps in our data and understanding, and inevitably assumptions have been made. It is a line in the sand that defines our current progress, and importantly outlines steps and actions we can now take to make a greater difference.

Any project such as this one benefits from specific and measurable objectives. We have tried to make our action plan specific and measurable where possible. We have intentionally stopped short of setting a goal date for total carbon emission reduction. We have not set a date or time that we believe we can hit 'net zero' across all our emissions. We simply do not understand the issues and implications well enough to do so. It would undoubtedly make for a more beneficial headline, but in the context of this issue we would rather concentrate on doing the right thing than making artificial claims.

Objectives

Our objectives at this stage are:

- Understand and publish our carbon emissions and carbon footprint publicly (delivered via this document).
- Understand where our priorities should be to reduce our carbon impact.
- Publish our sustainability actions and hold ourselves accountable for these.
- Identify where we need to improve our understanding and metrics.

DAVID & CHARLES

-PUBLISHING-

MISSION

Our mission is to create books and related products that ***ignite*** and ***nurture*** our readers' hobbies and interests.

VISION

We believe that hobbies and interests improve wellbeing and our society.

Our vision is to spread this positive impact to as many people as possible, delivering ideas, inspiration, and skills that empower people to learn and pursue their passions.

VALUES

- We do the right thing
- We express ourselves
- We do our best work
- We are better together
- We take pride in our independence and our Devon heritage

PURPOSE

We believe that by empowering people to learn new skills and explore their interests, we can create a brighter future.

Summary

David and Charles publish 60 new books per annum. In 2023, we shipped 1.2 million books worldwide. The company has 28 colleagues, working on a hybrid basis but with offices in Exeter. Our books are distributed through two lead distributors, GBS in the UK and Ingram Two Rivers in North America. Our books are printed with partners across 5 countries, but approximately 2/3 of our print is in China. Books are typically printed in China and shipped to UK and US distributors for onward sale to customers.

In this document we outline five areas of our business against which we can assess our carbon impact and identify tasks and actions for improvement.

This assessment gave us a total carbon impact of activities in 2023 of 2,622 CO2e tonnes per annum.

Outlined in this document are steps already taken. These include our requirement to print on FSC paper and our increased focus on editorial, design and production choices for the materials used in our books. We have educated ourselves to have a better understanding of the environmental impact of these finishes and choices.

We are a rurally located business, which inevitably means more travel and commuting miles by car. We have mitigated this with hybrid working and adopting video call technologies. A step further has been our lease of a hybrid car for company use and the installation of electric car charging points at our offices.

The metrics outlined in this document indicate that the direct ‘scope 1’ improvements we can make are important, but that our biggest impact is in 'scope 3' emissions. These are the emission costs from our 3rd party partners in print and supply chain.

Our biggest single improvement can come from addressing these areas, and the greatest priority for this is how we might improve the sustainability of our North American port to distributor land freight. That is a key focus of current work.

Figures in this document are sourced from two main sources:

- The Publishers Association Carbon Calculator, made available to us through our membership of the Independent Publishers Guild. We very much appreciate that access.
- In 2023, we were fortunate to work with Exeter MBA student Rahul Palekar. Rahul completed a comprehensive report on supply chain factors which is available in full in the appendix.

Structure and impact

We have identified five areas of business against which we can assess our carbon impact and identify tasks and actions for improvement. These are split across the direct emissions (scopes 1 and 2) and the indirect emissions (scope 3). These scope definitions are now widely used in sustainability planning and more information on these can be found online.

Scope 1 and 2 emissions	• Office and culture • Business travel
Scope 3 emissions	• Books and products • Supply chain (print and freight) • Distribution and customers • Suppliers and partners

The table below outlines our approach to measuring our impact in these areas and the resultant calculations of our CO2e emissions.

Area	**Impact Assessment and methodology**	**Calculations**
Scope 1 and 2		

Office and commuting	• Exeter office details:
	  ○ Square footage
	  ○ Electricity use*
	  ○ Gas use*
	• Staff commuting calculations: Mileage to office, frequency of travel.
	• Mileage of company 'pool car'
	
	Method: PA Carbon Calculator (through IPG access)
	
	**Offices are a shared tenancy. Calculations based on D&C share of building use.*
		38 CO2e tonnes per annum (tpa)
		
		Broken down as:
		Office: 9 CO2e tpa
		Company pool car: 4 CO2e tpa
		Staff commuting: 25 CO2e tpa

Business travel	• Air travel for business • Other journey travel for business (excluding pool car – see above) • Number of hotel nights booked in the year. Method: PA Carbon Calculator (through IPG access)	8 CO2e tonnes per annum

General suppliers (excluding print and freight)	Not assessed for this report.	
Scope 3		
Book printing	• Raw materials calculation at 0.864KG CO2e impact per book, based on a typical average format. • Print volumes taken from 2023 sales data Method: Exeter MBA Report (see appendix)	1,071 CO2e tonnes per annum

Book journeys / supply chain from printer to distributor	• Journey time calculations from printer to distributors (UK and North America)
	  ○ Printer to port
	  ○ Sea freight
	  ○ Port to distribution
	• Assumed all print is placed in China to allow for 'worst case'
	
	Method: Exeter MBA Report (see appendix)
		675 CO2e tonnes per annum

Book distribution from distributor to customer	• Estimated movement of goods from distributors (UK and North America) to end customers.	595 CO2e tonnes per annum
Customer distribution of books from warehouse to retail etc.	Not assesed for this report.	

Total 2023 impact of assessed activities

2,622 CO2e tonnes per annum

Achievements to date

Our commitment to the sustainability agenda has not been straightforward through COVID and the market dynamics of increased costs.

We have nonetheless strived to make progress and some of our notable achievements are:

- **A commitment to print all books on FSC paper where this is possible.**
  The exceptions to this are only those where necessary commercial format decisions or commercial timing constraints do not allow for it
- **An emphasis on making sustainable production choices.**
  Our sustainability Guardian represents these factors in our editorial, design and production processes so we can consider the carbon impact of finishing and other production choices.
- **A commitment to hybrid working.**
  With our rural location, necessitating commuting by car for most of the team, we are committed to hybrid working. This has reduced personal commuting miles by a factor of nearly 50%.
- **Use of video calls over travel.**
  Like many companies, we have adapted to the use of video calls. This has saved on domestic and international travel needs.
- **Office habits and recycling.**
  Our Exeter office has clear recycling points and we ensure that this is seen through to collection and waste disposal.
- **Lease of a hybrid pool car.**
  Our rural location requires us to travel often for business. The lease of a hybrid pool car ensures that where possible these journeys are made in the most sustainable way.
- **Electric car charge point at our Exeter office.**
  We installed an electric car charge point at our Exeter office in 2023 for use by staff and visitors.
- **Electric car salary sacrifice and bike to work schemes**
  Both of these schemes are available to staff to take advantage of.
- **Reduced flights to the Frankfurt book fair.**
  3 members of the team chose not to Fly to Frankfurt 2023 and shared the journey in our hybrid pool car.
- **Sustainability journey days HR policy**
  We added a policy to our HR terms that allows staff to take extra travel time for holiday when they select a sustainable choice over air travel.
- **Supplier questionnaires and supplier selection**
  We actively ask our suppliers for their sustainability policies when we are selecting who we work with and use this as part of the selection criteria.

Action plan

Area	Scope	Subject	Impact Assessment	Action
Office and culture	1 and 2	Office utility choices	PA Carbon Calculator	Making sustainable choices for office utilities: Gas and electricity. Explore options for on site renewables: Solar, air source. Complete as best as possible in respect of office tenancy
Office and culture	1 and 2	Office recycling	PA Carbon Calculator	Apply best practice recycling and sustainable behaviours in the office
Office and culture	1 and 2	Office printing	Internal / TBC	Reduce amount of office printing
Office and culture	1 and 2	Electric car charge point	PA Carbon Calculator	Electric car charge point
Office and culture	1 and 2	Company pool car	PA Carbon Calculator	Use hybrid vehicle for journeys where possible
Travel	1 and 2	Hybrid working	PA Carbon Calculator	Move to hybrid working reduces commuting hours.
Travel	1 and 2	Business air travel	PA Carbon Calculator	Reduce decisions to fly for business where possible. Car/train option
Travel	1 and 2	UK travel	PA Carbon Calculator	Reduce domestic travel where possible
Travel	1 and 2	Staff holiday travel	PA Carbon Calculator	Implement sustainable journey day policy
Books and products	3	Books printed on FSC paper	MBA Report	Print on FSC at all times
Books and products	3	Books printed on recycled paper?	MBA Report	Assess options for viability
Books and products	3	Recycling books	MBA Report	Assess viability to print on more recycle friendly paper stock and materials
Books and products	3	Finishes and production choices	MBA Report	Understand all impact. Have relative measurement of finishes and production choices
Books and products	3	Encourage printer feedback on format	MBA Report	Invite our printers to flag to us decisions that could reduce impact and be more sustainable.
Books and products	3	Impression level CO2E metrics	MBA Report	Work with the industry and Virtusales on defining clear metrics that can sit alongside financial goals

Supply chain (print and freight)	3	Printer paper mill selection	MBA Report	Ensure mills are using integrated v non integrated
Supply chain (print and freight)	3	Journeys printer > port	MBA Report	How can land freight to port move to electric trucks?
Supply chain (print and freight)	3	Journeys port > Distributor	MBA Report	How can land freight port to distributor move to electric trucks
Supply chain (print and freight)	3	US land freight to distributor	MBA Report	Can US land friend move from truck to rail due to distance
Supply chain (print and freight)	3	Shipping	MBA Report	Investigate sustainable shipping technologies/Partners
Distribution and customers	3	Engage distributors on policies and developments	Other	Work with Ingram, GBS and MDL on these
Distribution and customers	3	Returns issue	Other	Engage in industry initiatives
Distribution and customers	3	Overstocks and pulping	Other	Engage in methods to avoid this where possible
Suppliers and partners	3	Complete supplier survey on policies and behvaiours	Other	Complete survey in 2024
Suppliers and partners	3	Sustainability policies in supplier selection	Other	Apply criteria that incorporates sustainability policies.

Appendix

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FRONT PAGE

The Exeter MBA 2022/23

Full Project Title: Sustainable supply chain decision making: understanding and mitigating the supply chain environmental impacts for an independent illustrated book publisher

Word Count: 7132

Submitted by: Rahul Rajesh Palekar

to the University of Exeter as a Project towards the degree of **The Exeter MBA**

Declaration

- I certify that all material in this project which is not my own work has been identified and that no material is included for which a degree has previously been conferred upon me.
- I confirm that this project is my own work.
- I confirm that I have read and understood the University regulations on plagiarism* and I have properly acknowledged the work of others that I have included in this project.

Full name: Rahul Rajesh Palekar

Student ID number: 720001646

Date: 11/09/2023

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Student Candidate No: Your candidate number can be located via iExeter, Student Record System (SRS), collect candidate number for 2020/1, its 6 digits long. (Please note your candidate number will change every academic year).	252335
Assignment Title:	Sustainable Supply Chain Decision Making: understanding and mitigating the supply chain environmental impacts for an independent illustrated book publisher
Module Code:	MBAM914
Module Element Title:	Consultancy Project
Do you have an approved Individual Learning Plan (ILP)	No
If Yes to above, do you require and have approval for specific learning difficult marking guidelines (as outlined in the link below)? https://www.exeter.ac.uk/media/universityofexeter/wellbeing/documents/Dyslexia_Marking_Guidelines.pdf	No
Please provide any additional information relating to your ILP that you would like to bring to the attention of the marker:	N/A

Sustainable Supply Chain Decision Making

understanding and mitigating the supply chain environmental impacts
for an independent illustrated book publisher

Client: David & Charles

Academic Advisor: Dr. Merryn Haines-Gadd

Contents

Executive Summary

This project aims to assist the client, David & Charles, to make sustainable supply chain decisions. They currently print their books in China and ship them to warehouses in UK and US. The project aims to calculate the transport carbon emissions and give suggestions to mitigate the same. An additional objective of the project is to understand the carbon costs of book creation, in the hopes of creating more sustainable books in the future.

To calculate the carbon emissions of the transport, UK Government's emissions factor database was used. To calculate the embodied carbon in the book, the CCALC2 software, developed by the University of Manchester, was used. Scope boundaries were placed, described in the report.

The transport carbon analysis revealed that the use of diesel trucks from Baltimore port in the US, to Ingram warehouse in the US, caused the most carbon emissions (0.825kg CO_2e). This leg of the journey needed to be focused on, to mitigate carbon emissions.

A possible solution involved using rail as a medium to get the books from Baltimore to Ingram. A prospective service provider, Norfolk Southern, was contacted to discuss logistics. If their multi-modal solution were to be implemented, it would reduce the overall journey emissions by almost 50%. Similarly, electric trucks could be used to replace conventional diesel trucks in China and UK, where trucking distances are not great. Use of biofuels for shipping could be considered as a future use-case to decarbonise the sea-leg of the journey.

The embodied carbon analysis results revealed that paper was the overwhelming contributor to the book's carbon footprint. Focus was narrowed on the paper industry.

Papers produced in integrated mills (where pulping and final sheets of paper are made at the same place) have an overall lower carbon footprint than non-integrated mills. Research also reveals that recycled paper might not necessarily have low emissions, especially if recycling facility is not run on renewable sources. Use of integrated mills and recycled paper made using renewable energy could make books less carbon intensive.

Broader scopes and future avenues of sustainability are discussed at the end of the report.

Introduction

Client Overview

Established in 1961 in Newton Abbott, Devon, David & Charles (D&C) is a leader in illustrated non-fiction book publishing with a focus on craft, creative and wellbeing categories. It is currently based in Exeter, Devon, and has 22 employees (David & Charles, 2018).
After a period of American ownership, the current management team completed an MBO in 2019.

D&C publishes 45–50 new book titles each year, collecting a turnover of nearly £6m. Its books are sold globally, with roughly 50% of all sales coming from the North American market (Appendix V).

D&C's management are passionate about their business and the publishing industry and want to run a business in a way that considers the wellbeing of their staff, society, and the planet.

Project Overview

In mid-2019, at the time of D&C's MBO, the management set out a sustainability plan for the business and defined steps that they wanted to take to reduce the business' carbon footprint. The challenging global circumstances over the next 3 years (i.e., Covid-19, Brexit, Russia-Ukraine conflict) have made it difficult for them to deliver on their goals. Printing and paper prices have fluctuated in a way that has meant D&C has moved print from China, to Europe, Turkey, the UK, and back again.

Global freight prices have also varied significantly. Thus D&C have struggled to balance their sustainable objectives with the business demands of print costs and timings.

Currently, D&C prints books in China. They are then shipped to UK and US via sea freight. Then, they are transported from the port to the warehouses by trucks, before being distributed to retailers and other customers.

A proper understanding of the environmental impacts of this current supply chain will go a long way in developing a strategy to mitigate those very effects. This will empower D&C's sustainability push and make them a more responsible business. Additionally, D&C plays an active part in industry groups, such as the Independent Publishers' Guild. It can thus provide some thought leadership in these groups, and the findings from this project could be used across the book publishing industry in the UK to make more sustainable supply chains.

The problem statement is:

"What are the environmental impacts of David & Charles' supply chain choices, and how might they be reduced, while being mindful of costs and operational efficiencies?"

The context of the problem is a combination of sustainability and operations challenges. Since the core aim of the company is to ensure that its supply chain choices are the least carbon intensive as possible, it is necessary to first calculate the carbon footprint of D&C's supply chain decisions. Second, the book creation process will also be investigated to uncover any potential improvements as well.

The analysis will help to uncover key areas of emissions, and then solutions will be identified and investigated. Implementing these solutions might involve breaking away from the traditional way of doing business, including changing printing location, changing order sizes, or changing logistic arrangements. This could raise costs or hamper organisational deadlines.

To this end, some key project objectives will be:

- Calculating the carbon footprint of transporting the books from China to UK and US
- Calculating embodied carbon in the books
- Uncovering which sections of the supply chain and book have the greatest carbon impact
- Investigating low impact alternative solutions
- Understanding the business consequences of implementing potential low impact alternatives and devising actionable solutions

Literature Review

The publishing industry concerns itself with the design, preparation, and sale of books. Its supply chain involves forest management, paper production, ink and glue manufacturing, printing press, and cross-continental freight services, among other elements. Naturally, this leads to negative environmental impacts.

For a publishing house, office activities and energy use (Scope-1 and Scope-2) make up only a small part of their overall carbon footprint (Penguin Random House UK, 2022; The Guardian, 2022). Most of the emissions are contributed by scope-3 (supply chain) entities.
Globally, publishing houses are in various stages of their decarbonisation journeys. Although most have begun measuring and mitigating their scope-1 and scope-2 emissions, not all of them have made progress on scope-3 emissions. This is understandable, since working on scope-3 emissions involves extensive data collection from both upstream and downstream supply chain partners.

Environmental impact can be measured via carbon accounting or life cycle impact assessments.

Carbon accounting is "a technique used by analysts and management teams to understand the extent of an organization's carbon emissions – both direct and indirect" (Peterdy, 2022). It concerns itself with only carbon dioxide emissions. GHG accounting, on the other hand, expands the scope of footprinting to include all greenhouse gases.

Life Cycle Impact Assessment (LCA), also referred to as 'cradle to grave analysis', is a process of evaluating the environmental impacts of a product over various stages of its life (European Environment Agency, 2023). This is a detailed analysis of a single product, and contains calculations such as water use, waste generation, energy use, ozone depletion and many more.

Organisations in the publishing industry generally calculate their carbon emissions using external consultants. These organisations have a wide range of products, each with their own distinct supply chain journeys. This makes it very difficult to accurately calculate the carbon impacts of organisations. It is more efficient to estimate the overall impacts using the companies' spending and sales figures, which are aggregated.

Specialised processes like LCA are not typically used in the industry currently. However, one of the goals of this project is to measure the carbon impacts of the book creation process. Since this is a specific topic, an LCA analysis will be worthwhile in calculating the embodied carbon in books. This project will enable a better understanding of the carbon costs of book creation, through the lens of viewing the book as a singular product.

The environmental impacts of the paper industry are very closely linked to the publishing industry. The general trend among the publishing industry is that the upstream carbon costs of paper manufacturing are the greatest contributors to the overall supply chain emissions (Penguin Random House UK, 2022; The Guardian, 2022). This is usually followed by the transport of raw materials and the finished goods to their respective destinations.

Forest Stewardship Council (FSC) is the current industry standard for responsible forest management, recognised by over 50% of consumers worldwide (Forest Stewardship Council, 2023). Paper is sourced from forests managed by FSC, under a strict set of guidelines. These guidelines limit the

number of trees cut, their locations in the forest, restrict use of pesticides, and aim to protect the rights of indigenous peoples living in the forest (World Wildlife Fund, 2018).

The inks used in books often contain heavy metals such as barium, zinc, or copper, which are hazardous to both human health and environment (Tian & Martin, 2012). Water based, Oil based, or Electronic Beam inks are considered better alternatives to these (Book Chain Project, 2021). Of these, oil-based inks are seeing eco-friendly alternatives, such as soy-based oils being used instead of the usual petroleum bases (Tian & Martin, 2012).

The carbon calculation of the book will also entail understanding the paper-making process, since paper is a majority constituent of the book. Currently, the papermaking process goes as follows (Britt, 2020):

1. Wood is cut, washed, dried, and turned to chips
2. Chips fed into a 'digester', separating plant fibers
3. Bleached to whiten
4. Squeezed and pounded into pulp, making it flexible
5. Formed into sheet, excess water removed
6. Sheet dries to form paper

By conducting a carbon analysis of the book as a product, this study will shed some new light on the constituents of a book, and how the processes behind book-creation can be improved.

Methodology

Scope setting

The client produces a variety of books for many markets (US, UK, Asia, Australia, Africa), therefore it is necessary to set a scope and boundaries enable effective and focused research. The following scope boundaries have been put in place for this project, with discussion and approval of the client:

- For the supply chain analysis, impact will primarily be measured in terms of released carbon emissions.
- David & Charles publishes books in various styles and formats. Based on the sizes of the display cases in the stores where the books are sold, D&C uses certain common dimensions while designing most of its books. These characteristics are:
    - 550gm weight
    - 128 pages
    - 273mm high x 210mm wide
    - Paperback
    - Section sewn binding (ie the book is sewn not glued)
    - Printed 4/4 (4 colour on all pages front and back) internal pages. 4/0 on the cover (inside cover pages are blank)
    - FSC paper
    - 300gsm paper weight cover; 128gsm Matt Art paper internal pages
    - Matt lamination on the cover
- Although some of the books are printed digitally, the project will consider only the traditional printing process (offset printing), since it is used in more than 95% of their total design projects.
- The project will limit itself to the books printed in China and delivered to the warehouses in UK and US. The UK and US make up for most of the client's sales worldwide.
- The scope of the supply chain study will be from printer to warehouse.

For the embodied carbon emissions of the books, the following scope boundaries were put in place:

- Carbon footprint of all constituent materials of the book to be measured. This would only include the carbon cost of manufacturing said materials.
- Emissions due to transport of raw materials from mills/factories to the printing press are out of scope. This is because data collection for this would have to be done by the printing press, which is not the central organisation of the project.
- Energy Emissions of book printing to be excluded for simplicity.
- Carbon costs of making lithographic plates to not be considered for simplicity.

The report will now look at the resources and tools employed to work on each of the two defined problems.

Choice of Software and Tools

There were several options for the choice of software and tools to make the transport and embodied carbon calculations. Some of them were:

- The Ecoinvent database, in conjunction with OpenLCA, an open source LCA software. The Ecoinvent database is a paid access database, used popularly by sustainability professionals around the world (Ecoinvent, 2022)
- The University of Exeter (UoE) carbon accounting tool. This is an internal tool developed by the UoE IT team for calculating the carbon footprint for all journeys across UoE.

- The ‘Carbon Calculations over the Life Cycle of Industrial Activities’ (CCALC2), a free carbon footprinting tool developed by the University of Manchester (University of Manchester, 2016)
- Greenhouse gas conversion factors database (Department for Energy Security and Net Zero & Department for Business, 2022)

Ultimately, the Greenhouse gas conversion factors database was used for measuring the carbon footprint of freight choices. This was because the database is government published, making it widely acceptable and well regarded.

The Ecoinvent data base is the most comprehensive and widely used data base for LCA assessments, however considering the needs and budget constraints was deemed not appropriate. Therefore, the CCALC2 software was used, as it still is based on the Ecoinvent data but uses a smaller data set which suits the needs of this small study. The limited access included data on paper production, printer ink, and cloth production.

The report will now go over the supply chain and embodied carbon results, discussions, and recommendations in sequence.

Study 1: Supply Chain Carbon Footprinting

Findings/Results

In order to determine the best decarbonisation strategies for transport in the supply chain, it was necessary to understand the entire supply chain, and calculate the carbon emissions for each leg of the book's journey, from the printer in China to the client's warehouses in the UK and the US.
In order to do this, the client's logistics partner was sent a survey asking them to share the logistics of the journey the books made from printer to warehouse. Distances between locations were calculated using Google Maps (Google, 2023) for land and Ship Traffic (Ports.com, 2023) for sea.

Once the details of the journey were mapped, the GHG Conversion Factors database (Department for Energy Security and Net Zero & Department for Business, 2022) was used to calculate the carbon emitted per book with a weight of 550g.

Based on their inputs, the following journey was mapped, along with the carbon emissions:

a. Printer to UK warehouse

	Leo printers to Yantian port	Yantian port to Felixstowe port	Felixstowe port to Grantham warehouse
Distance (km)	186	20496	220
Transport type	Truck	ship	Truck
Emissions factor (per ton per km)	1.13	0.01	1.13
Emission per ton (kg CO2e)	210.18	204.96	248.6
Emission for 550g book (kg CO2e)	0.115	0.112	0.136
Leo Printers to Grantham Warehouse Total (kg CO2e)		0.363	

Table 1: Journey and emissions details from Leo Printers (China) to Grantham warehouse (UK). (Source: Magnum Logistics)

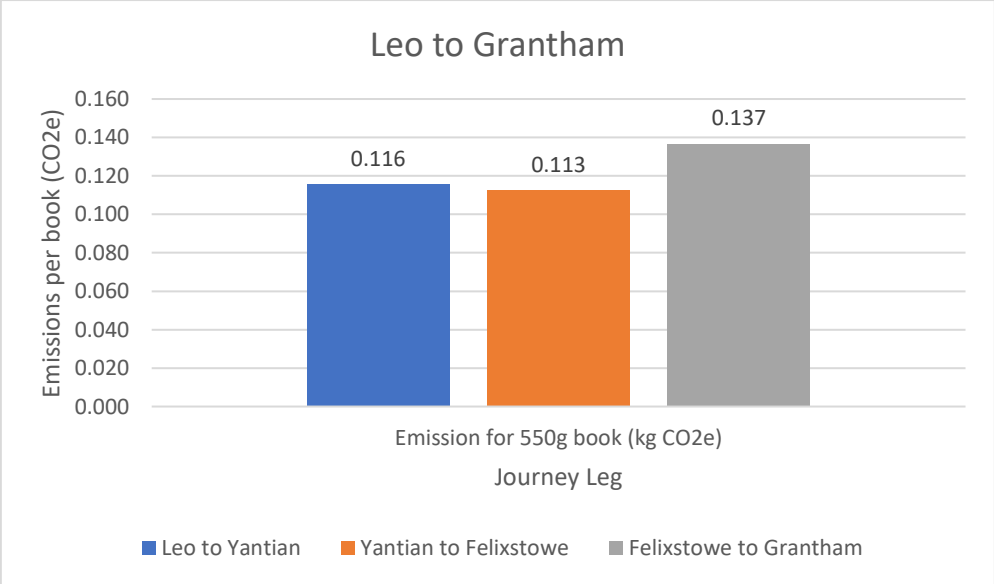

Figure 1: Comparison of journey legs (China to UK)

b. Printer to US warehouse

	Leo printers to Yantian port	Yantian port to Baltimore port	Baltimore port to Ingram warehouse
Distance (km)	186	24377	1329
Transport type	Truck	ship	Truck
Emissions factor (per ton per km)	1.13	0.01	1.13
Emission per ton (kg CO2e)	210.18	243.77	1501.77
Emission for 550g book (kg CO2e)	0.115	0.134	0.825
Leo Printers to Ingram Warehouse Total (kg CO2e)		1.075	

Table 2: Journey and emissions details from Leo Printers (China) to Ingram warehouse (US). (Source: Magnum Logistics)

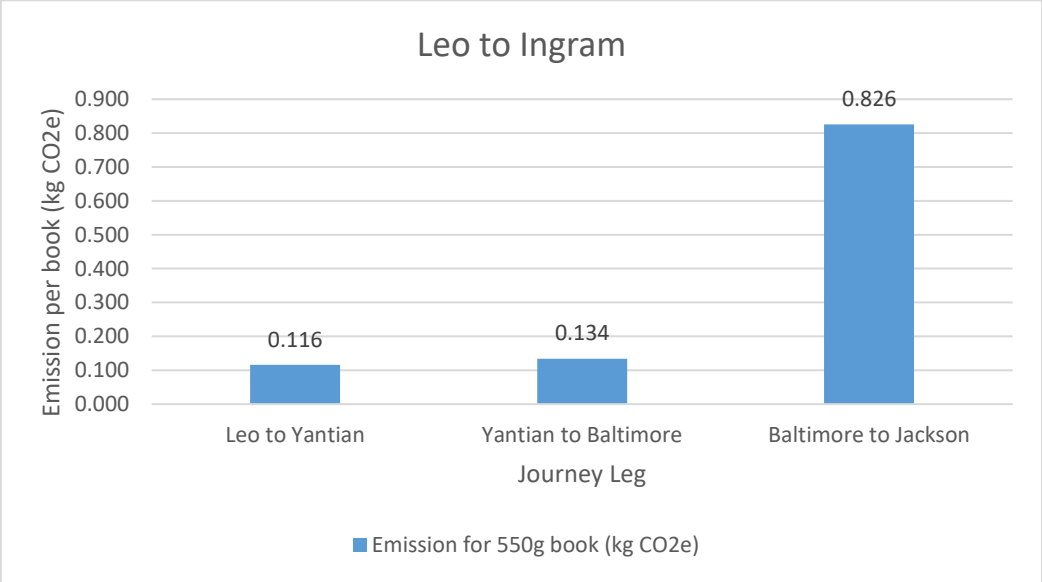

Figure 2: Comparison of journey legs (China to US)

From Fig. 1 and Fig. 2, it is clear that the land journey from Baltimore port to the Ingram warehouse at Jackson, Tennessee is the largest contributor to the total carbon emissions of the transport. Additionally, the brief by the client states that US sales make up for roughly 50% of all sales. This means that the US leg of the journey is more carbon intensive than the other legs, and also occurs more often. Thus, it is critical that this leg of the journey is addressed first, in terms of carbon emissions.

This would mean that the UK emissions journey must be considered at a later date.

The high emissions are because Heavy Goods Vehicles (HGVs) run on diesel and have a far larger emission factor than ships, which run on fossil fuels but also transport huge loads over large distances (Department for Energy Security and Net Zero & Department for Business, 2022). This greatly brings down the 'carbon emitted per tonne of weight carried per kilometre' for ships.

Discussion & Recommendations

Discussion

From Fig. 2, it is clear that the US land leg of the book journey is responsible for the maximum carbon emissions (0.826kg of CO_2e per book). Also, US sales make up more than 50% of David & Charles' overall sales (Appendix V). Therefore, it makes sense to mitigate the US emissions first. This would potentially lead to the most carbon reduction.

This reduction could be done by either reducing the distance travelled (i.e. changing location of port or warehouse), or by changing the mode of freight to something less carbon-intensive.

i.) Changing the location of the port: The ship docks at Baltimore port, located on the eastern coast of the US. The books are then freighted via truck to Jackson, Tennessee, which is located in the southeastern part of the US. The distance covered is 1329km (Google, 2023).

Alternate ports on the eastern coast could be Jacksonville, Florida (1159km), Savannah, Georgia (1000km), New Orleans, Louisiana (719km), and Charleston, South Carolina (1093km), among others (World Port Source, 2023). If books are trucked from any of these ports to Jackson, TN, there will be reduced emissions due to the lower distances.

However, there are some challenges to this method. The books are shipped in 40' High Cube containers (Appendix II), which have a capacity of 76.3m^3 (Hapag-Lloyd, 2023). Since David & Charles prints roughly 5000 books in one print run (David & Charles, 2023), it does not move enough books to fill the entire container on its own. Magnum Logistics, the logistics partner of D&C, sometimes pairs the D&C books with shipments from other book companies to fill the container to capacity. After reaching the port of Baltimore, the books might then be loaded into separate containers, and sent their separate ways.

To move the location of the port, Magnum would have to convince the other book company to have their books delivered to the other port as well, so that the container-sharing arrangement may continue. This might not be ideal for the other company, especially if their warehouse is closer to Baltimore. Else, both D&C as well as the other company would have to find new organisations to share container space with.

ii.) Changing the location of the warehouse: The warehouse is located at Jackson, TN, and is managed by Ingram Publisher Services (Appendix II). After books reach the warehouse, they are further distributed to book retailers such as Amazon, Waterstones, and Barnes and Noble.

Moving the warehouse closer to the port of Baltimore will reduce the trucking distance of the books. But it will also change the distances covered by the trucks to go from the warehouse to the retailers.

Although the book journey from warehouse to retailer is not in the scope of the project, it is important to consider the wide-scale supply chain disruption that would be caused by moving one of the most focal points in the entire supply chain: the warehouse.

If the warehouse were to be moved to such a location where all journeys to retailers would cumulatively be the shortest, it would cut down the overall emissions significantly. However, it would still be an unfeasible idea because of the sheer logistical restructuring required to put it into place. Each retailer journey would have to be renegotiated from the new place, possibly with other logistic partners. Hence, the warehouse location should not be changed.

iii.) Changing transport medium: Currently, Magnum uses diesel trucks hauling 19,000kg containers in the US (Appendix II). These trucks emit 1.13kg of CO_2e per tonne cargo per km, making them one

of the most carbon intensive modes of transportation (Department for Energy Security and Net Zero & Department for Business, 2022). Replacing them with less carbon-intensive alternatives would be effective in decarbonising the transport supply chain. Two such alternatives are electric trucks and rail freight.

Electric Trucks: In the past few years, electric long-haul cargo trucks have made an appearance in the international market. Mainstream models, such as the Volvo FH Electric, can carry up to 44 tonnes over 300km on a single charge (Volvo, 2023). Such a truck would be able to carry the 19-tonne container in which the books are usually transported.

For the sake of simplicity, the report assumes Volvo FH Electric as the freight truck model. As per the calculations in Appendix I, the electric truck will emit 0.024kg of CO_2 per book transported from Baltimore to Jackson. This is much better than the 0.826kg emitted by diesel trucks currently. Using electric trucks would reduce the carbon emissions of the overall journey (end to end) by 74.5% (Appendix I).

One of the greatest benefits of using EV trucks is that no major logistical changes have to be made in order to accommodate them. The ships can dock in the same port, travel to the same warehouse, and pair their cargo with the same book companies. The only difference will be that the trucks would be electric.

However, there would be certain challenges in implementing EV trucks in the transport supply chain. The distance between Baltimore port and Ingram warehouse at Jackson, TN, is 1329km (Appendix II, Google, 2023). The trucks have a range of up to 300km (Volvo, 2023). This means that each truck would need to be charged more than four times in order to make the journey. This raises the issue of range anxiety and charging time.
There are enough charging stations (both DC and AC) in the US to recharge between Baltimore and Jackson (U.S. Department of Energy, 2023). But each recharge will take 10 hours with an AC charging point or 2 hours with a DC charging point (Volvo, 2023). This will not only increase the cost of the journey, but also the time required. Additionally, the drivers might also be entitled to more pay, due to higher journey time. This will further raise costs.

It is important to note that the journeys from Leo Printers to Yantian port in China, and from Felixstowe port to Grantham warehouse in UK, are 186km and 220km respectively (Appendix II, Google, 2023). Both these journeys could be made in a single charge of an electric truck (Volvo, 2023). Therefore, it makes sense to shift these journeys from conventional trucking to electric trucking.

Rail freight: Freighting goods by rail is one of the most carbon friendly modes of moving goods on land. Trains emit only 0.027kg CO_2e per km per ton of weight carried by them (Department for Energy Security and Net Zero & Department for Business, 2022). This is mainly due to trains being able to carry vast amounts of goods across great distances in a single trip.
Rail freight has historically been cheaper than trucking, especially over long distances (RSI Logistics, 2020). Additionally, rail freight also has limited negative externalities. Research by Forkenbrock (2001) shows that trucking has higher external costs to society, namely accidents, pollution, and noise. Although the study does not consider electric trucks, it is clear that rail freight is the better environmental option when measured against conventional trucking.

However, rail freight comes with its own set of challenges. Unlike trucks, trains do not have the freedom to move to absolutely any place they want. This makes them reliant on multi-modal transport to complete the ‘last-mile’ connectivity. In the case of D&C, a prospective rail freight

operator was identified and contacted to understand the feasibility of moving goods from Baltimore to Jackson by rail.

Norfolk Southern: To cover the journey between Baltimore (MD) and Jackson (TN), rail freight operators active on the eastern coast of the US were investigated. Among them, Norfolk Southern stood out as an operator which has expertise in transporting forest goods such as paper products, and whose operating range covers Baltimore and Jackson (Norfolk Southern, 2016, 2023).

On communication with Norfolk Southern representatives (Appendix III), a possible solution was proposed. Goods would be transported to their Elizabeth (NJ) terminal, where they could be unloaded in their facility. Since they do not do 'less than container load' shipments, they could either:

a) Pair D&C shipments with other clients to have a full load
b) Consolidate multiple D&C shipments into a single intermodal container to obtain a full load

The Elizabeth facility has the option to hold and consolidate multiple shipments. Delays of a few days in shipments to the warehouse were not expected to be a problem, since the books were not required urgently (Appendix II).

Once consolidated to a full load, the books would then be sent to Memphis via rail. They would finally complete the last leg of the journey to Jackson, via truck.

The following Table 3 displays the carbon emissions resulting from a multi-modal method of freighting, as described by Norfolk Southern above:

	Leo printers to Yantian port	Yantian port to Baltimore port	Baltimore port to Linden, NJ	Linden, NJ to Memphis	Memphis to Ingram warehouse
Distance (km)	186	24377	287	1800	146
Transport type	Truck	ship	truck	rail	truck
Emissions factor (per ton per km)	1.13	0.01	1.13	0.027	1.13
Emission per ton (kg CO2e)	210.18	243.77	324.31	48.6	164.98
Emission for 550g book (kg CO2e)	0.115	0.134	0.178	0.027	0.091
Leo Printers to Ingram Warehouse (using rail freight) Total (kg CO2e)		0.546			

Table 3: Journey and emissions details from Leo Printers (China) to Ingram warehouse (US), using rail freight. (Source: Magnum Logistics, Norfolk Southern)

It can be seen that the final carbon footprint comes in at 0.546kg CO_2, which is an almost **50% reduction** from the previous Leo to Ingram journey.

Recommendations

Based on the analysis of electric trucks and rail freight, D&C should implement the following changes:

1. Switch China and UK land freight modes to electric trucks

The journeys from Leo Printer to Yantian Port and from Felixstowe Port to Grantham Warehouse are both under 300km (Appendix II, (Google, 2023)). A standard electric truck can cover this distance in a single charge, making it convenient and potentially not so expensive (Volvo, 2023). Additionally, it would also bring down the emissions by 97%: a significant amount (Appendix I).

2. Switch US land freight to rail

Since the books are freighted over large distances in the US, an electric truck might not be the best solution. As discussed in the earlier section, the truck would have to be recharged as many as four times in the entire journey. This will increase travel time and costs, owing to additional charging costs and driver costs.

Although rail freight will involve operational complexities such as consolidation of shipments and multi-modal journeys, it will employ a traditional mode of freighting and the costs will not be as high (RSI Logistics, 2020).

In order to implement this solution and work out the finer logistical details, further steps will be taken by D&C and Magnum, in consultation with Norfolk Southern, or other suitable rail freight operator.

3. Investigate sustainable shipping technologies

Currently, most ships use petroleum-based energy sources, such as heavy fuel oil, marine gas oil, marine diesel oil, or intermediate fuel oil (Tan et al., 2022). These give rise to sulphur oxides and nitrogen oxides in emissions, leading to environmental concerns.

One alternative is the use of biofuels. These are made by converting biomass into fuel. If bio-waste is used as a feedstock to create biofuels, the fuels could be considered sustainable (Ovrum, 2023). These can then be used as ‘drop-in’ fuels, meaning they can be mixed with conventional fuels, without having to modify or change the ship engine in any way (Ovrum, 2023). This has made them an attractive proposition for decarbonising the shipping industry.

This is yet an emerging industry, but carbon insetting services such as ‘GoodShipping’ have already begun offering services to switch conventional sea fuel with biofuel. As biofuels become more commercially viable in the future, sea-freighting could become much more environmentally friendly.

Study 2: Embodied Carbon in books

Findings/Results

To understand the total embodied carbon in the books, it was necessary to understand the entire book creation process, including the various constituent elements of a book and how they come together. The client graciously arranged a visit to Short Run Printing Press (SRP), a local Exeter-based printing company.

Book Creation Process

The book creation process can be described as this:

Stage 1: Printing the paper (Monotone – 1 plate/CMYK – 4 plates/Pantone – 5 plates)

- Press machine is used according to the size of the paper sheet used at input.
- SRA 1 press - medium size paper sheet
- B1 press - larger size paper sheet
- The paper could be any GSM and type (silk/matt/gloss/etc.) as long as dimensions are adhered to

Result after printing: Large sheets with 16 or 32 pages printed on them

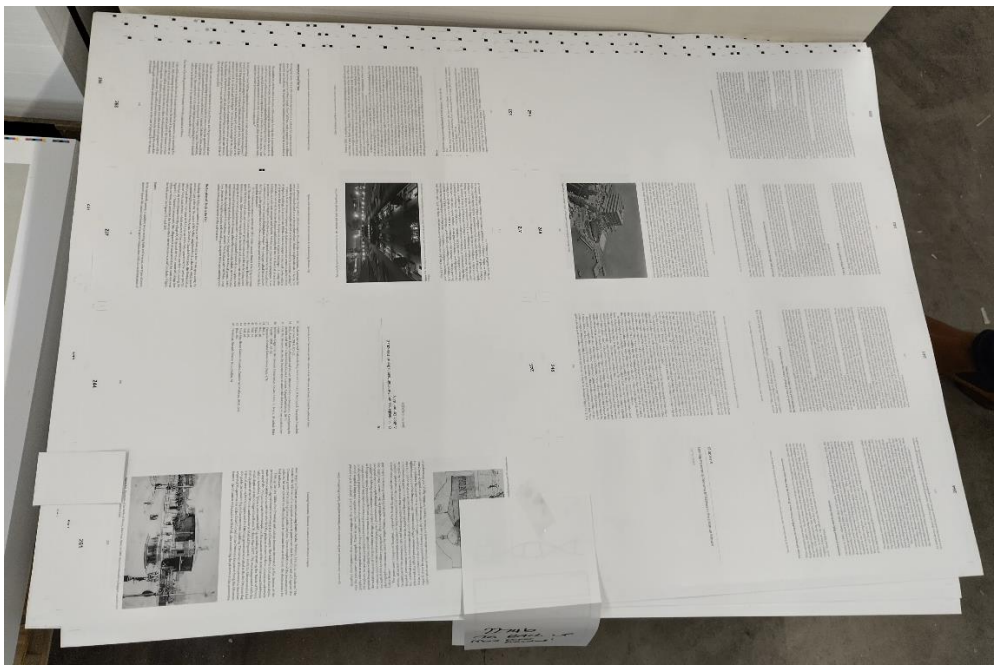

Figure 3: This large sheet has 32 pages printed on it (Clicked at SRP with permission)

Stage 2: Folding

- The single paper with multiple printed pages is folded down to book size
- Page size can be adjusted for folds (A3, A4, A5, etc.)

Result after folding: Folded sheets which are the size of pages

Stage 3: Sewn Binding

- Sheets sewn together using sewing binding machine.
- Cover to be glued on using separate machine - could be paperback or hardback

Result after sewing: Sewn pages

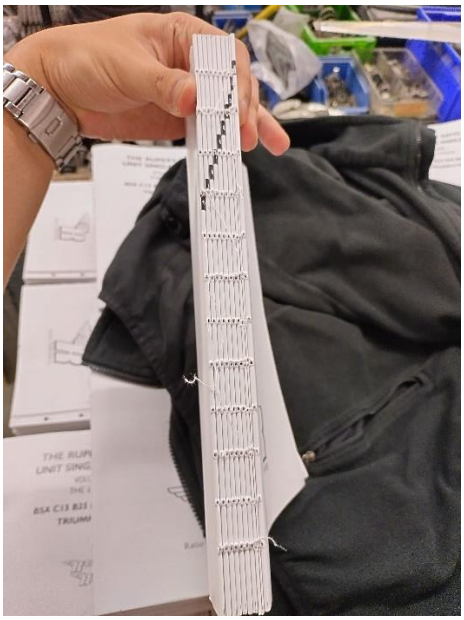

Figure 4: Pages sewn together (Clicked at SRP with permission)

Stage 4: Gluing the cover

- Cloth lining to protect the sewing
- Gluing paperback cover on the pages

Result after gluing: Book ready

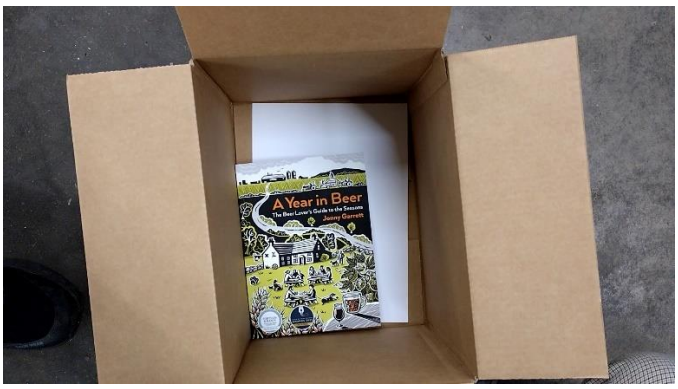

Figure 5: Complete book in a box, ready for packing (Clicked at SRP with permission)

Stage 5: Packing

- Packing books in boxes. Boxes are in 3 standard sizes in SRP: Full perimeter pallet, European pallet, Small pallet. 5 boxes on top of each other max.
- Different warehouses accept different sizes of pallets.
- Boxes are protected around the edges wrapped in plastic by a machine after being loaded on the pallet. Extra empty boxes at the top sometimes, to deter transporters from loading more pallets on top and crushing the books.

Result after packing: Books ready to ship.

Figure 6: Books packed and wrapped. Ready to be freighted. (Clicked at SRP with permission)

Thus the constituents of the book can be described as paper, inks, glue, thread, and cloth.

Measuring individual book constituents

In order to understand the total embodied carbon in the book, it is necessary to take apart the book to weigh the individual components. The individual components could then be added by weight into the CCALC2 software to determine their carbon footprint.

In order to do this, a sample book was provided by the client. The book (Edward's Menagerie Birds) had the same characteristics as the assumed book used for all calculations so far (128gsm, 300gsm paper weight cover; 128gsm Matt Art paper internal pages, 128 pages, 273mm high x 210mm wide, Paperback).

The cover was separated from the pages. This exposed the glue and the cloth protecting the spine of the book. The constituents were measured as follows:

i. Paper (pages)

Each page measures 0.273 x 0.21 m. Its density is 128 gsm. Since the book has 128 pages, it consists of 128/2 = 64 sheets of paper.

Therefore, the total weight of the pages in the book is: (64 x 128 x 0.273 x 0.21) g = 469.6 g

ii. Paper (cover)

2 sheets of paper, measuring 0.273 x 0.21 m. Density 300gsm.

Total weight of cover: (2 x 300 x 0.273 x 0.21) = 34.2 g

iii. Ink

In order to measure the weight of the ink on the paper, a high-accuracy digital weighing scale was used. It gave readings with the accuracy of one-thousandth of a gram. Two pages from the book were cut out: one with minimal graphics and text on it (acknowledgements page), and one with the maximum graphics and text (action page). Both of them were weighed on the scale thrice, to avoid any inconsistencies in weighing.

Attempt	Acknowledgements page	Action page
#1	6.53g	6.59g
#2	6.54g	6.59g
#3	6.54g	6.59g
Average	6.54g	6.59g

Table 4: Weights of acknowledgements and action pages

The action page, with its colourful graphics and text, weighs 0.05g more than the acknowledgements page. Now, the action and acknowledgements pages are at the opposite ends of the 'ink use' spectrum. Making an assumption that all pages will have ink density somewhere between the two measured pages, the average of the two could be taken to account for ink weight per page.

Assuming the weight of ink on the acknowledgements page to be a negligible 0.01g, the average ink per page comes to 0.035g per page. This comes to 2.27g for the entire book, including the cover.

iv. Glue

The glue is applied to the spine of the book, so that the cloth may cover the spine. To measure the weight of the glue, the area of the spine was measured. It came to be 273mm x 8mm. Assuming the glue was 1mm thick on application, the volume of glue came to be 273 x 8 x 1 mm^3.

The density of binding glue (Polyvinyl Acetate) is 1.19 g/cm^3 (Kettering University, 2023). Thus, the weight of the glue comes out to be 2.59g.

v. Thread

Unfortunately, the thread could not be isolated due to it being covered by the binding glue and the protective cloth. Due to this, calculations could not be done.

vi. Cloth

The cloth covers the spine of the book, measuring 273mm x 8mm. It is a gauze cloth, having density of around 130gsm (Wicked Fabrics, 2023). Thus, weight of the cloth comes to be 0.28g.

Calculating embodied carbon

Once the constituent elements of the book have been isolated and measured by weight, the details can be fed into the CCALC2 software, to calculate their carbon footprints.

The individual elements on the book (paper, ink, glue, fabric) were entered in the CCALC2 date base and revealed:

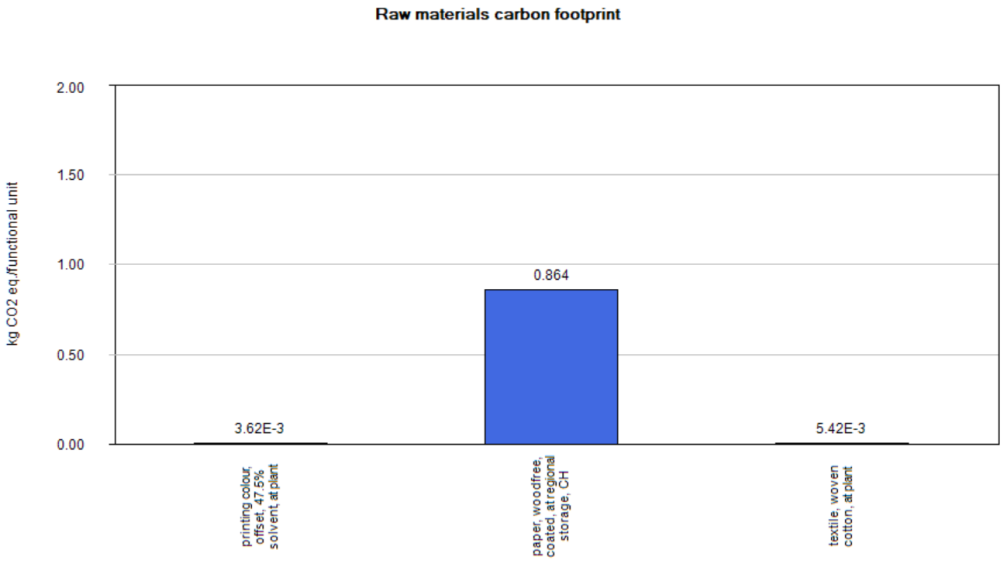

Figure 7: CO2e embodied in book by raw materials
(Source: CCALC2 software, using the Ecoinvent database)

Fig. 7 shows the breakdown of carbon emissions by raw materials. It is important to note that the emissions of glue were not included since the Ecoinvent database employed by the CCALC2 software did not have the required glue details.

It can be seen how the paper emissions were the most significant and make up the majority emissions of the book. This is not surprising, since paper makes up the majority of the overall weight of the book.

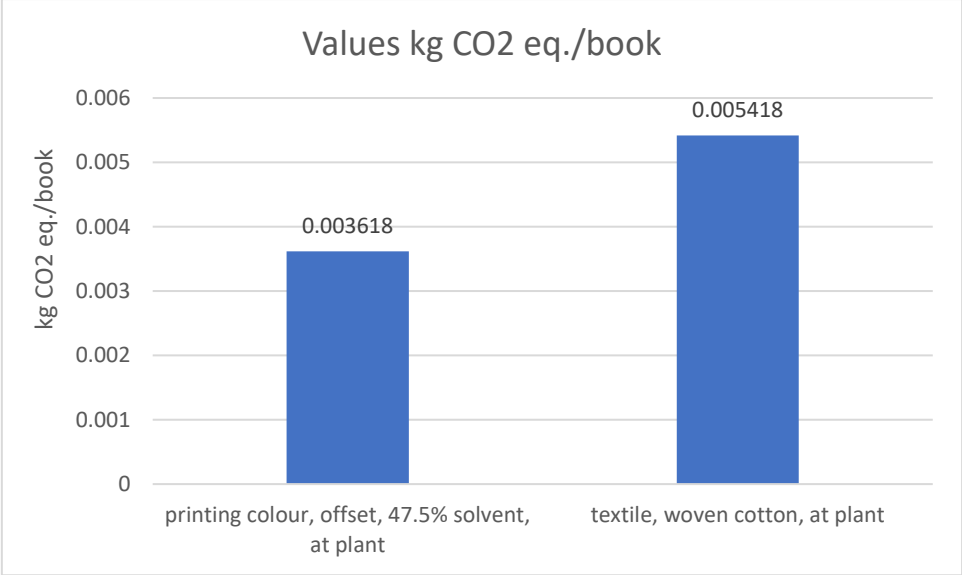

Figure 8: Comparison between ink and cloth emissions in book creation
(Source: CCALC2 software, using the Ecoinvent database)

Among the other two, cloth emissions take up a larger share than ink emissions. Fig. 8 shows that the cloth emissions are roughly 1.5 times that of ink emissions.

Discussion & Recommendations

Discussion

This report will now delve deeper into paper. From Fig. 3, it can already be seen that the paper causes the most emissions, compared to inks, cloth, and presumably glue. Based on the information shared by D&C and Leo printers (Appendix IV), the paper will be classified as coated, woodfree and non-recycled.

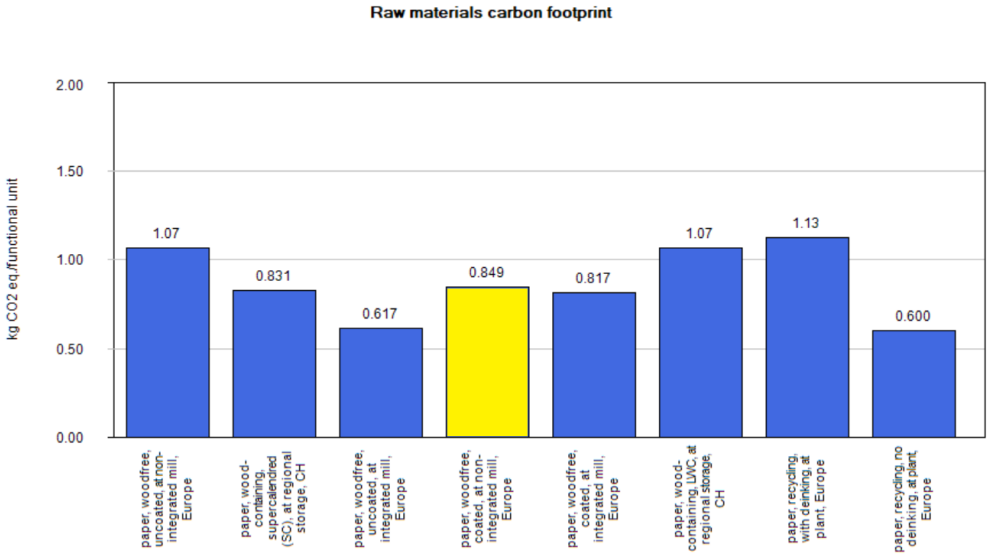

Figure 9: Comparison of CO2e of various types of papers, for 0.724g
(Source: CCALC2 software, using the Ecoinvent database)

Fig. 9 shows the comparison of the various types of papers. The paper used by D&C is highlighted in yellow. It is on the higher end of the carbon emissions spectrum but is far from the highest emitting type of paper.

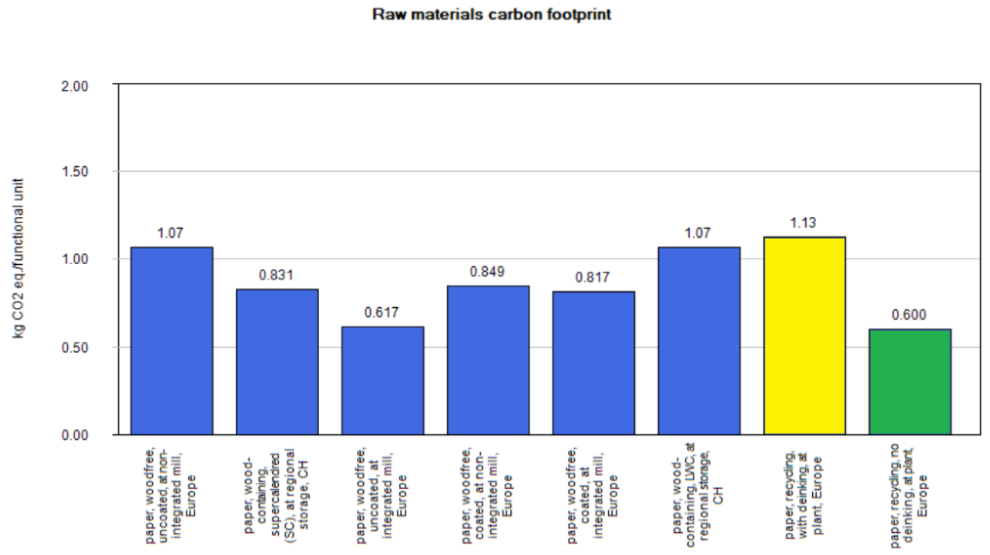

Figure 10: Recycled paper has the largest carbon footprint of all (Source: CCALC2 software, with Ecoinvent database)

That distinction goes to the deinked recycled paper (marked in yellow), as shown in Fig. 10. It is important to note that recycled paper without deinking (marked in green) has the least carbon

footprint. Although recycling has always been considered as a ‘green’ alternative irrespective of industry, it might not always be the best choice in all circumstances.

A modelling study by researchers from Yale and University College London (University College London, 2020) found that carbon-based electricity used in recycling plants is more environmentally expensive than the cost of cutting trees to make paper. Additionally, recycling also involves setting up reverse logistics in the supply chain, making it more environmentally and financially expensive. The research found that shifting recycling plants to renewables would help massively in reducing the overall carbon impact of recycled paper, to the tune of up to 96% (ibid).

Another key feature observed in Figs. 9 and 10 is that integrated mills are always more carbon friendly than non-integrated mills. Integrated mills are mills where the wood is converted into pulp, and the pulp is converted into paper, all in the same site. Whereas non-integrated mills simply convert the wood to pulp in one facility, sell the pulp into the market where it is purchased by another facility, which converts it into paper (United States Environmental Protection Agency, 2022). Thus, integrated mills don’t have to deal with the burden of transportation of pulp. Research from The Book Chain Project (2021) further proves that integrated mills are less carbon intensive, across various world regions. Although sometimes non-integrated mills display lower carbon intensity in scopes 1 and 2 as compared to integrated mills, they do so because they have outsourced the pulping or paper production to another mill, which moves the emission to scope 3.

Choosing whether the paper is recycled or from an integrated mill is a choice that a publisher can make without major changes to the type of paper. As Figs. 9 and 10 show, qualities of paper such as wood-containing vs. woodfree, coated vs. uncoated, also have varying carbon footprints. But making these changes will affect the quality of creative output. Hence, these will have to be investigated at a later stage.

Recommendations

Paper is the biggest contributor in embodied carbon emissions of the book. Therefore, the recommendations will focus on mitigating paper emissions.

1. Source paper from integrated mills

This will avoid the carbon costs of drying the pulp, as well as transporting it to a different paper mill, to be converted into sheets. However, it is important to note that all of the publisher's paper needs might not be fulfilled by integrated mills. Integrated mills, by definition, need to be located at places where there is a forest. This makes their presence limited by geography.

Non-integrated mills can often turn out to be cheaper, due to them buying their pulp from the open market. This gives them more flexibility to change their suppliers. D&C will need to carefully balance their integrated and non-integrated paper mix for optimal sustainability and supply chain resilience.

2. Use recycled paper

The book printer can also use recycled paper to print its books. Care must be taken to ensure that the recycling facilities use renewable energy. This is likely very difficult, since China is overwhelmingly reliant on coal and oil for its energy needs (International Energy Agency, 2023).
Recycled paper made using renewable energy could be used for digital printing projects, that happen locally in the UK (David & Charles, 2023). However, it might also cost more, and that should be factored in while making decisions (Anderberg Print, 2020).

Conclusions & Future Scope

The project calculated the carbon footprint book transportation and embodied carbon in books, for D&C.

Truck journeys in the US were identified as the single biggest contributor to the overall journey carbon footprint. Rail freight was investigated as an option to replace trucking, and looks like a promising alternative, with further investigation to be carried out by D&C and Magnum logistics. Use of electric trucks in China and UK, and use of biofuel powered shipping could be explored to decarbonise the other legs of the transport supply chain.

In embodied carbon analysis, paper was revealed to be the most significant contributor of carbon emissions. Using integrated mills and recycled paper made from renewable energy will reduce the carbon footprint of the book.

This project has exclusively focused on carbon. It is important to note that although carbon footprinting is necessary to limit global warming to below 1.5^0C by the turn of the century, it is not the only aspect of sustainability. Waste management, biodiversity impact assessments, reuse economy, and many more perspectives can also be considered, which were not covered by this report. It might be worthwhile to explore the possibility of making completely recyclable books, for instance. This will require both, detailed data on constituent materials, as well as the logistics to ensure that books are recycled at the end of their lives.

Large companies in the print and publishing industry are trying out new things in their sustainability journeys. As industry leaders, their sustainability reports can be read and followed for best practices. Some possible ideas include: Researching biodiversity impacts and removing wrapping from print products (The Guardian, 2022), increasing print-on-demand services and donating excess stock (Taylor & Francis, 2023), moving towards digital offerings (Springer Nature Group, 2022), investigating sustainable marketing (Oxford University Press, 2023), or creating publishing design guidelines for sustainable books (Penguin Random House UK, 2022). D&C can also engage in greening their office spaces, using renewable energy to power office, and adding in the option of working from home to remove commute emissions.

Ultimately, the client will have to decide what sustainability means for them. Carbon footprinting acts as a nice gateway into the world of sustainability. As the client conducts their own research into what is possible, they will be able to visualise the different paths they can take to make their business ‘environment-friendly’.

References

Anderberg Print. (2020, August 12). *Why Does Recycled Paper Cost More Than Brand New Paper? | Anderberg Print*. Anderberg Print. https://www.anderbergprint.com/blog/why-does-recycled-paper-cost-more-than-brand-new-paper

Book Chain Project. (2021). Resources - Book Chain Project. In *Book Chain Project*. https://bookchainproject.com/resources

Britt, K. W. (2020, January 10). *Papermaking | Process, History, & Facts | Britannica*. Britannica. https://www.britannica.com/technology/papermaking

David and Charles. (2018, December 6). *About - David and Charles - Find out more about us here.* David and Charles. https://davidandcharles.com/about-david-and-charles/

David & Charles. (2023). In-person meetings. David & Charles, Pynes Hill, Exeter.

Department for Energy Security and Net Zero, & Department for Business, E. & I. S. (2022, September 20). *Greenhouse gas reporting: conversion factors 2022 - GOV.UK*. GOV.UK. https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022

Ecoinvent. (2022, December 15). *ecoinvent Database - ecoinvent*. Ecoinvent. https://ecoinvent.org/the-ecoinvent-database/

European Environment Agency. (2023). *life cycle assessment — European Environment Agency*. European Environment Agency. https://www.eea.europa.eu/help/glossary/eea-glossary/life-cycle-assessment

Forest Stewardship Council. (2023). *How the FSC System Works | Forest Stewardship Council*. Forest Stewardship Council. https://fsc.org/en/how-the-fsc-system-works

Forkenbrock, D. J. (2001). Comparison of external costs of rail and truck freight transportation. *Transportation Research Part A: Policy and Practice*, *35*(4), 321–337. https://doi.org/10.1016/S0965-8564(99)00061-0

Google. (2023, May). *Google Maps*. Google. https://www.google.com/maps/@19.1389388,72.8397314,15z?entry=ttu

Hapag-Lloyd. (2023). *40' Standard High Cube - Hapag-Lloyd*. Hapag-Lloyd. https://www.hapag-lloyd.com/en/services-information/cargo-fleet/container/40-standard-high-cube.html

International Energy Agency. (2023, May 23). *China - Countries & Regions - IEA*. International Energy Agency. https://www.iea.org/countries/china

Kettering University. (2023, September 5). *Synthetic Polymers - EP 342: Materials Science - LibGuides at Kettering University*. Kettering University Library. https://libguides.kettering.edu/c.php?g=473752&p=3241844

Norfolk Southern. (2016). *System Maps, Directories & Schedules | Shipping Tools | Norfolk Southern*. Norfolk Southern. http://nscorp.com/content/nscorp/en/shipping-tools/system-maps-directories-schedules.html

Norfolk Southern. (2023). *Agriculture and Forest Products | Shipping Options | Norfolk Southern*. Norfolk Southern. http://nscorp.com/content/nscorp/en/shipping-options/agriculture-and-forest-products.html

Ovrum, E. (2023, June 22). *Exploring the potential of biofuels in shipping - DNV*. DNV. https://www.dnv.com/expert-story/maritime-impact/Exploring-the-potential-of-biofuels-in-shipping.html

Oxford University Press. (2023). *Responsible Publishing Report*. Oxford University Press. https://oup.foleon.com/responsible-publishing-report-2022-23/2022-23/

Penguin Random House UK. (2022). *Zero Journey to Forward from CEO of Penguin Random House UK*.

Peterdy, K. (2022, February 14). *Carbon Accounting - Overview, Scope 1, 2, & 3 Emissions*. Corporate Finance Institute. https://corporatefinanceinstitute.com/resources/esg/carbon-accounting/

Ports.com. (2023, May). *Sea Distance Calculator | ShipTraffic.net*. ShipTraffic.Net. http://www.shiptraffic.net/2001/05/sea-distances-calculator.html

RSI Logistics. (2020, April 20). *Comparing the Costs of Rail Shipping vs Truck - RSI Logistics*. RSI Logistics. https://www.rsilogistics.com/blog/comparing-the-costs-of-rail-shipping-vs-truck/

Springer Nature Group. (2022). *DRIVEN BY DISCOVERY Sustainable Business Report 2022 WELCOME TO SPRINGER NATURE*.

Tan, E. C. D., Harris, K., Tifft, S. M., Steward, D., Kinchin, C., & Thompson, T. N. (2022). Adoption of biofuels for marine shipping decarbonization: A long-term price and scalability assessment. *Biofuels, Bioproducts and Biorefining*, *16*(4), 942–961. https://doi.org/10.1002/BBB.2350

Taylor & Francis. (2023). *Sustainability - Taylor & Francis*. Taylor & Francis. https://taylorandfrancis.com/about/corporate-responsibility/sustainability/

The Guardian. (2022). *Positive Impact and Sustainability Report*.

Tian, X., & Martin, B. (2012). Business model sustainability in book publishing. *Publishing Research Quarterly*, *28*(2), 100–115. https://doi.org/10.1007/S12109-012-9258-3

United States Environmental Protection Agency. (2022, December 30). *Pulp and Paper Production (MACT I & III): National Emissions Standards for Hazardous Air Pollutants (NESHAP) for Source Categories | US EPA*. United States Environmental Protection Agency. https://www.epa.gov/stationary-sources-air-pollution/pulp-and-paper-production-mact-i-iii-national-emissions-standards

University College London. (2020, October 19). *Paper recycling must be powered by renewables to save climate | UCL News - UCL – University College London*. University College London. https://www.ucl.ac.uk/news/2020/oct/paper-recycling-must-be-powered-renewables-save-climate

University of Manchester. (2016, December 12). *CCaLC • CCaLC2 for Windows Carbon Footprinting Tool*. University of Manchester. http://www.ccalc.org.uk/ccalc2.php

U.S. Department of Energy. (2023). *Alternative Fuels Data Center: Electric Vehicle Charging Station Locations*. Alternative Fuels Data Center. https://afdc.energy.gov/fuels/electricity_locations.html#/find/nearest?fuel=ELEC

U.S. Energy Information Administration (EIA). (2022, November 25). *Frequently Asked Questions (FAQs) - U.S. Energy Information Administration (EIA)*. U.S. Energy Information Administration (EIA). https://www.eia.gov/tools/faqs/faq.php?id=74&t=11

Volvo. (2023). *Volvo FH Electric | Volvo Trucks*. Volvo. https://www.volvotrucks.com/en-en/trucks/trucks/volvo-fh/volvo-fh-electric.html

Wicked Fabrics. (2023, September 10). *100% Cotton Double Gauze in 'Petrol' 130GSM | OEKO-TEX® 100 | European - 50CM*. Wicked Fabrics. https://www.wickedfabrics.com.au/100-cotton-double-gauze-petrol-130gsm-50cm/

World Port Source. (2023). *World Port Source - Ports with Liner Service in United States*. World Port Source. http://www.worldportsource.com/shipping/country/ports/USA.php

World Wildlife Fund. (2018, April 22). *Want to help save the world's forests? Look for the FSC logo when you shop | Stories | WWF*. World Wildlife Fund. https://www.worldwildlife.org/stories/want-to-help-save-the-world-s-forests-look-for-the-fsc-logo-when-you-shop

Appendix I – UK Government Emissions Database

1. Trucking

			100% laden
Activity	Type	Unit	Total kg CO_2e per unit
HGV (all diesel)	Rigid (>3.5 - 7.5 tonnes)	tonne.km	0.26396
		km	0.54291
		miles	0.87373
	Rigid (>7.5 tonnes-17 tonnes)	tonne.km	0.14556
		km	0.71483
		miles	1.15041
	Rigid (>17 tonnes)	tonne.km	0.1255
		km	1.13291
		miles	1.82324
	All rigids	tonne.km	0.13346
		km	0.95522
		miles	1.53726
	Articulated (>3.5 - 33t)	tonne.km	0.07428
		km	0.96112
		miles	1.54675
	Articulated (>33t)	tonne.km	0.05989
		km	1.08375
		miles	1.74412
	All artics	tonne.km	0.06017
		km	1.0787
		miles	1.736
	All HGVs	tonne.km	0.07384
		km	1.02944
		miles	1.65671

Table 5: Emissions Factors for freighting goods via diesel-based Heavy Goods Vehicles (HGVs) (Source: UK Government)

2. Rail

Activity	Type	Unit	Total kg CO_2e per unit
Rail	Freight train	tonne.km	0.02782

Table 6: Emissions Factors for freighting goods via rail (Source: UK Government)

3. Ship

Activity	Type	Size	Unit	Total kg CO_2e per unit
Cargo ship	Bulk carrier	200,000+ dwt	tonne.km	0.00254
		100,000–199,999 dwt	tonne.km	0.00304
		60,000–99,999 dwt	tonne.km	0.00416
		35,000–59,999 dwt	tonne.km	0.00578
		10,000–34,999 dwt	tonne.km	0.00801
		0–9999 dwt	tonne.km	0.02961
		Average	tonne.km	0.00354
	General cargo	10,000+ dwt	tonne.km	0.01207
		5000–9999 dwt	tonne.km	0.01602
		0–4999 dwt	tonne.km	0.01409
		10,000+ dwt 100+ TEU	tonne.km	0.01115
		5000–9999 dwt 100+ TEU	tonne.km	0.01774
		0–4999 dwt 100+ TEU	tonne.km	0.02008
		Average	tonne.km	0.01323
	Container ship	8000+ TEU	tonne.km	0.01267
		5000–7999 TEU	tonne.km	0.01683
		3000–4999 TEU	tonne.km	0.01683
		2000–2999 TEU	tonne.km	0.02028
		1000–1999 TEU	tonne.km	0.03255
		0–999 TEU	tonne.km	0.03681
		Average	tonne.km	0.01614
	Vehicle transport	4000+ CEU	tonne.km	0.03245
		0–3999 CEU	tonne.km	0.05840
		Average	tonne.km	0.03858
	RoRo-Ferry	2000+ LM	tonne.km	0.05019
		0–1999 LM	tonne.km	0.06114
		Average	tonne.km	0.05166
	Large RoPax ferry	Average	tonne.km	0.37667
	Refrigerated cargo	All dwt	tonne.km	0.01308

Table 7: Emissions Factors for freighting goods via Sea (Source: UK Government)

4. Electric Trucks

Baltimore to Jackson		0.387kg CO2 per KWH (U.S. Energy Information Administration (EIA), 2022)
1329km		540KWH per charge = 300km (Volvo, 2023)
e-truck		1329 / 300 = 4 charges
		4 charges = 2160KWH = 835.92kg CO2
		For 550g book = 24.19g CO2
Kg CO_2		0.024

Table 8: Electric truck emission calculations

Emissions due to diesel HGVs = 0.825 kg CO_2

Reduction in emissions due to EVs = 97%

Reduction in overall emissions (Leo to Ingram) = 74.5%

Appendix II – Logistics details shared by Magnum

(Extracted from email communications with Magnum Logistics, edited for relevance and clarity)

Q1. What is the journey undertaken by the books from printer to warehouse (both UK and US)? Including ports and cities/towns. Can you confirm routes taken:

A.

Far East to UK: Arrival Port/ truck
Far East to US; Arrival Port/ truck or Rail to Ingram?
UK to US: Arrival Port/truck to Ingram?
Far East to UK: Arrival Port/ truck
Far East to US; Arrival Port/ truck or Rail to Ingram
UK to US: Arrival Port/truck to Ingram

Port of discharge is as follows:

Yantian to Ingram: Baltimore Port.
Yantian to GBS: Felixstowe.
UK to Ingram: Southampton to Chester

Majority of books from the printer to loading warehouse or unloading warehouse to destination is shipped by truck / road freight.

Leo Factory address:

Heshan Astros Printing Ltd
Xuantan Temple Industrial Zone, Gulao Town
Heshan, Guangdong, China

The warehouse in the UK is GBS: located at

Trent Road
Grantham
NG31 7XQ

Ingram is located at:

Ingram Publishing Services Inc.
210 American Drive
Jackson, TN 38301

Q2. Cooling employed during transport, if any?

A. Some trucks in the US have cooling facilities but these are usually used for food / produce.

Q3. Type of container

A. We ship 40'HC containers every time. you can load to the UK up to 24,000kg / 65cbm per container. The US you can load between 19,000 – 22,000kg / 65 cbm.

Q4. Capacity of truck/lorry in metric ton (weight range would do, this is just to estimate the size).

A. The US have weight limits and will not load more than 19,000kg per trailer. The UK, you can load 24,000kg onto a trailer and into Europe as well.

Q5. Are multiple trucks required to transport books from port to warehouse? If so, how many?

A. If we are talking container haulage, no. one trailer per container. We ensure the containers are shipped to the closest port and are usually 1 hour / 90 minutes away to unloading facility in the UK and US.

Q6. Are trucks or ships completely loaded?

A. Magnum load full trailers and containers but when it comes to capacity on the vessel – this would be a question for the shipping lines. The rates have dropped so would suggest there may be space on the vessels.

Q7. What is the time taken for books to be delivered from Baltimore port to Ingram?

A. Around 10 days.

Q8. The shipping container contains D&C books along with books from other publishers. Once the container arrives at the Baltimore port, do the other books go their own separate ways? Or are they also loaded onto the same truck, where they get dropped off on the way?

A. This can depend on what has been loaded into the container. If other freight for Ingram, this will load with D&C orders. If for other destinations, it may possibly deliver on the same vehicle however not always. The volume of freight we have delivering to Ingram would normally be a truck load anyway as we are able to mix China and UK freight together.

Appendix III – Details shared by Norfolk Southern

(Extracted from email communications with Norfolk Southern, edited for relevance and clarity)

Q1. We currently use Magnum Book Services for our China > USA freight. Magnum are publishing industry focused and they consolidate books from several publishers into containers from China to Baltimore, where they are then split for onward delivery. In our case, our distributors are based in Jackson and delivery is to their warehouse.

I'm not sure if you have ever worked with Magnum Book Services at all?

I think a question at this stage might be if you work with any other book publishers, or freight forwarders moving books, and possibly with any that are delivering to Jackson? If so, it would be interesting to know who and which port(s) are involved as I suspect it might be easier for us to see how feasible it is to follow an existing routing than try and figure out something new.

A. With the current once a week volume, intermodal service with transloading at origin or destination may be the best path forward. Our Baltimore intermodal lanes primarily services the Chicago market. Our most flexible option now is out of our Elizabeth, NJ terminal. We can bring containers into our facility and unload them. We do not currently load out LCL intermodal containers to Memphis today. The value would be having a full load of Jackson, or the ability to consolidate multiple shipments into a single intermodal container. We have current options to hold and consolidate multiple shipments. We do not currently have a relationship with Magnum Book Services, but I see they are in Linden, NJ and are less than 20km from the port and 30km to our intermodal yard. Although we are not familiar with other book services, we are familiar with some great freight forwarders in the area. The Elizabeth/Linden, NJ area may be the most flexible area for intermodal access and door to door service to Jackson.

Here are some solution options for our existing intermodal lanes:

- Bring it to our warehouse in Elizabeth to deconsolidate and build our intermodal containers to Memphis to deliver direct in Jackson. (We would need to know the unidentified shipments remaining and source transportation)
- Establish relationship with Magnum in Linden and run door to door intermodal moves to Memphis/Jackson. (To get most value, we would need a full container)
- Establish relationship with another freight forwarder currently using intermodal to possibly match other Memphis freight to build full container loads?

Appendix IV – Paper details

(Extracted from email communications with Leo Paper, edited for relevance and clarity)

Q1. Where is the paper mill located? How is paper transported from mill to Leo?

A. For the 128g matt art paper, brand name Snow Eagle FSC or Golden Sun FSC , we used on most of your orders are located in ShanDong province, China, ship by sea to factory.

The 300g C1S board we used on covers, brand named EUCA FBB FSC, IS located in ZHANJIANG city, Guangdong province , China, ship by railway to factory.

Q2. Does the paper mill use renewable energy? What is the energy mix used by it?

A. Waiting for answers from supplier.

Q3. Is the mill integrated or non-integrated?

A. Waiting for answers from supplier.

Q4. Is the paper (128gsm, matt art paper) coated or uncoated?

A. COATED

Q5. Is the paper (128gsm, matt art paper) wood-containing or woodfree, LWC or MWC or Supercalendered?

A. WOODFREE

Q6. Is the paper (128gsm, matt art paper) recycled or non-recycled? If recycled paper: is it deinked or non-deinked?

A. FSC PAPER NOT RECYCLED

Appendix V – David & Charles Project Brief

Organisation description

David and Charles is a leader in illustrated non-fiction book publishing with a focus on craft, creative and wellbeing categories. From our base in Exeter, Devon, we publish 45–50 new book titles each year. The company was originally founded in 1961. After a period of American ownership, the current management team completed an MBO in 2019. The period since then has been an interesting one to run any business (through Brexit, Covid and the war in Ukraine), but throughout David and Charles' sales have seen healthy growth.

The business has a turnover of near £6m and 22 employees. We sell our books globally, with roughly 50% of all sales coming from the North American market.

We are passionate about our business and the publishing industry and want to run a business in a way that considers the wellbeing of our staff, society, and the planet.

Project background

In mid-2019, at the time of our MBO, we set out a sustainability plan for the business and defined some steps that we wanted to take to reduce our carbon footprint. The challenging circumstances over the past 18/24 months have made it difficult to deliver on our goals. Printing and paper prices have fluctuated in a way that has meant we have moved print from China, to Europe, Turkey, the UK, and back again. Global freight prices have also varied significantly. We have struggled to meet the business demands of print costs and timings, while delivering on sustainable objectives.

We also do not have a full understanding of the relative carbon cost of our supply chain choices. How much worse from an emissions perspective is it to print books in China and ship to the UK and US compared with a UK or European printing, for example? What is the extent of carbon benefit to holding books in China so that we can consolidate shipping with other print runs? How can we manage that while still meeting our business goals? Is rail freight from China a credible option?

There may also be wider industry decisions we can take. Print on Demand (where you print a single book to order) or short run digital printing runs are a growing feature in the industry, and both of these allow us to reduce the freight miles of books from printers to distributors. However, these choices come with cost and operational constraints. Perhaps there are ways we could look at this differently.

Project objectives

• A thorough understanding of the relative carbon/environmental costs of our supply chain choices (print and production, freight and shipping, distribution). This can perhaps be translated into a series of 'book journeys', with the different print and distribution choices understood.

• An understanding of the carbon costs of book creation, covering all elements (paper, glues, inks, printing).

• A realistic appraisal of the choices and changes the business can make to reduce our carbon footprint.

• If feasible, a timeline towards becoming a net zero business.

• A much deeper understanding of the environmental cost of doing business, and where we can make change.

Why this work is important to the organisation

For reasons that I would assume are obvious, this is an incredibly valuable and important project for us.

The nuance of this project is to understand how we can make meaningful change within the constraints of an SME such as ourselves. We can move quickly and be nimble in our decisions, but we must work within cost and timing requirements for our business to be successful and profitable.

Deliverables

Compulsory:

• 6500-word consultancy report (needed for academic assessment purposes).

Client requested deliverables:

• A summary of emission metrics for the different supply chain choices available to us.

• A summary of findings and recommendations that the business can review. Ideally presented to the Directors.

• If possible, a pathway / action plan towards net zero.

Why should students choose this project

We are an independent publisher that works on a global scale and has market leadership in our categories. In recent years we have been award winning, fast growing and have been featured in the publishing industry as a result of our success. Most recently we were the South West regional featured publisher in The Bookseller magazine.

We play an active part in industry groups, such as the Independent Publishers' Guild. We can provide some thought leadership in these groups, and our findings from this project have the potential to educate and influence across the industry.

As a relatively small organisation with a flat hierarchy, any student can gain access to the team and our day-to-day business very quickly. We can make decisions and changes without lengthy review, and so there is an opportunity for this project to make a real difference.

Primary contact during the project

James Woollam, Managing Director

How will the student be expected to interact with the organisation

This can really be defined by whatever interaction benefits the student and project most. We have a hybrid office environment, with most members of the team working 2/3 days in the office and 2/3 days at home. Our staff are happy to interact in person or on video call. Any student is welcome to spend as much or as little time in the office as they wish.

If required, we can also arrange calls or even visits with 3rd parties such as our distributors or suppliers. It might be valuable for a student to visit a local printer, for example, just to get a full understanding of the processes involved in printing.

Company policies

There are no specific policies that should cause an issue with this project.

Acknowledgements

The author would like to thank the following individuals for their contributions to the project:

Name	Position at University of Exeter	Role
Dr. Merryn Haines-Gadd	Postdoctoral Research Associate	Project supervision, Research Guidance, Guidance on Carbon Calculations and methodology development

Name	Position at David & Charles	Role
James Woollam	Managing Director	Co-ordinating and communicating with supply chain partners, arranging printer visit, arranging books for calculations
Beverly Richardson	Production Manager	Co-ordinating and communicating with supply chain partners, sharing information
Bridget Joliffe	Finance Director	Co-ordinating and communicating with supply chain partners, sharing information
Colin Carter	Office Manager	Arranging books for calculating embodied carbon

Also, in alphabetical order:

Name	Position	Role
Ben Murray	Sustainability Manager, Guardian News & Media	Shared information and insights on sustainability in the publishing industry, best practices, possible avenues of research & exploration
Catherine Hodgson	Sustainability Manager, Taylor & Francis Group	
Molly Hawes	Senior Climate Action and Engagement Manager, Springer Nature Group	
Oliver Gadsby	President, Independent Publisher's Guild Non-Executive Chair, Zero Carbon Academy	
Simon Crump	Environmental Consultant, Book Industry Communication Ltd.	
Simon Graham	Chief Knowledge Officer, Zero Carbon Academy	
Zoe Cokeliss Barsley	Director of Sustainability, Oxford University Press	
Ceri Linton	Senior Analyst, Anthesis Group	Introduced carbon footprinting and LCA resources, indicated helpful questions to ask supply chain partners
David Parker	Ex-Principal Consultant, Oakdene Hollins	
Meenakshi Menon	Sustainability Consultant, Eight Versa	