

Institution: Royal Holloway, University of London		
Unit of Assessment: 17 Business and Management Studies		
Title of case study: Expanding and consolidating supply chains in the UK composite materials sector through the establishment of a specialist database (the 'HUB')		
Period when the underpinning research was undertaken: 2014-2020		
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:
Dr Adrian Coronado Mondragon	Senior Lecturer in Technology and Operations Management.	2011-date
Professor Paul J. Hogg	Vice Principal for Innovation and Regional Affairs	2012-date
Period when the claimed impact occurred: 2014-2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact The composite materials industry is estimated to be worth GBP4,800,000,000 to UK high-tech manufacturing. 'The HUB' database – developed by the team headed by Dr Coronado Mondragon – is the first comprehensive database created exclusively for the needs of the UK's composite materials sector. It covers 45% of all UK composite companies (600 companies), and users report that it has expanded and consolidated supply chains in the UK's composite materials sector. The HUB benefits the UK composite businesses by facilitating business deals, identifying supply chain partners, finding materials, equipment and software, customers to target, marketing products, performing competitor analysis, benchmarking, developing patents, and raising the visibility of UK composite businesses to companies abroad.		
2. Underpinning research Context The composite materials industry will play an increasingly important role in UK high-tech manufacturing and is expected to reach GBP9,500,000,000 by the year 2030. Composite materials consist of a matrix material, which is a polymer based resin, surrounding and supporting a reinforcement of some kind (typically fibres, particles or flakes). The resultant properties are more advantageous compared to those of either the matrix or the reinforcement when used on their own. Composite materials are used in applications that cover aerospace, defence, automotive, rail, construction, marine, oil and gas and renewable energy. Key findings The aims of Dr Coronado Mondragon's research project (the 'Comp-Fore Project') was to promote growth and enhance relationships between businesses comprising supply chains in the UK composites industry. This industry is a major supplier to key sectors including defence, aerospace, automotive. The Comp-Fore project was awarded GBP500,000 as part of the Government-funded Advanced Manufacturing Supply Chain Initiative (AMSCI) under the Composites Innovation Cluster (CIC) consortium of projects, which was designed to improve the global competitiveness of UK advanced manufacturing supply chains. Selecting new materials and manufacturing technologies represents a major challenge to businesses with implications that affect the configuration of the composite materials supply chain. More specifically, the supply chain involved in the manufacture of composites parts faces challenges that include whether a technology can be introduced based on material availability,		

rate/process cascade effects, skills availability, and lead times. Dr Coronado Mondragon's research (see R1) investigated the selection process by administering a questionnaire survey designed to identify the importance and interrelationships between 18 key factors important to manufacturing in high-technology supply chains. The survey was distributed to 271 companies who were members of Composites UK in 2014 and achieved a response rate of about 30%.

Key findings from the survey showed three factors receiving the highest ratings, namely 'on time deliveries/service level to customers', 'improve quality' and 'reduce cycle time' (R1, which became the basis for R2). Furthermore, a correlation analysis identified the underlying dependencies between these and the remaining 18 factors, and showed that the core factors supporting manufacturing were 'supply chain performance', 'reduce scrap and rework', 'reduce inventory levels', 'return on investment' and 'hiring/training staff'. The analyses provided a comprehensive picture of the factors that affect manufacturing technology selection in composite supply chains. Two industry experts in composite materials commented on the survey results and how they could be best applied to the composites industry (R1). Further research was based on a case study during 2014 to 2015 involving site visits and interviews with senior management, and evaluated the merits of twelve factors affecting manufacturing technology selection with respect to the supply chain (R2). The analysis of empirical data revealed how supply chain-related factors are more important than those directly related to the technical merit of the technology such as low-cost manufacturing or automation.

How the research led to the impact

The survey and case study findings (R1 and R2) served as the foundation to two major tools designed to assist companies in the composite materials sector facing challenges associated with selection processes. The tools comprise the HUB composites capabilities database – a specialist database for identifying supply chain partners – and a supply chain reconfiguration software tool. The HUB database schema included field type definitions that were derived from the research undertaken, including materials used in production, equipment/software used in production, semi-finished materials, processes used in production, products manufactured, services provided, and geographical proximity. An organizational case study illustrated the benefits of the HUB database and software tool to the composites manufacturing process (R3).

3. References to the research

- R1.** Coronado Mondragon, A. E., Mastrocinque, E., and Hogg, P. (2017). Technology selection in the absence of standardised materials and processes: a survey in the UK composite materials supply chain. *Production Planning & Control* Vol. 28, 2, pp. 158-176. <http://dx.doi.org/10.1080/09537287.2016.1252070>. QI: CABS 3* journal
- R2.** Coronado Mondragon A.E., Mastrocinque, E., Tsai, J-F., and Hogg, P. (2019). An AHP and fuzzy AHP multi-factor decision-making approach for technology and supplier selection in the high-functionality textile industry. *IEEE Transaction on Engineering Management* E-pub. DOI: 10.1109/TEM.2019.2923286 or via <https://ieeexplore.ieee.org/document/8758398> QI: CABS 3* journal
- R3.** Coronado Mondragon A.E., Coronado Mondragon C., Hogg, P. and Rodriguez-Lopez, N. (2018). A design process for the adoption of composite materials and supply chain reconfiguration supported by a software tool. *Computers & Industrial Engineering* Vol. 121, 62-72. <https://doi.org/10.1016/j.cie.2018.05.022> . QI: CABS 2* journal

4. Details of the impact

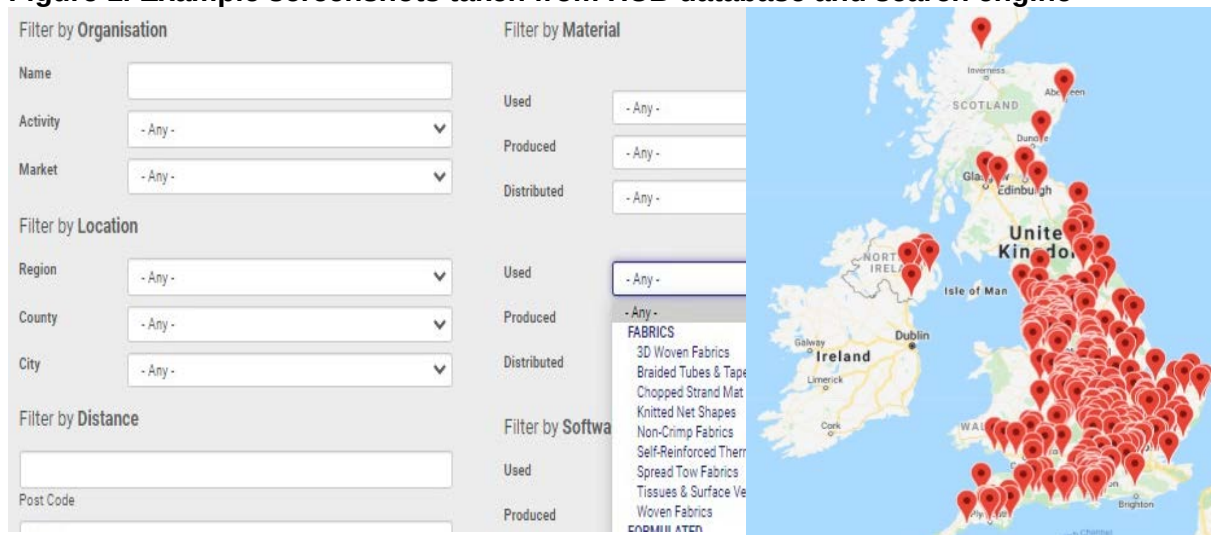
The main beneficiaries of the HUB are composites manufacturers in the UK, new product developers, innovators, researchers, and the trade body Composites UK (the trade body for the UK composites industry). The benefits include **identifying supply chain partners**, facilitating **business deals**, **finding materials, equipment and software**, **customers to target**, **marketing products**, **performing competitor analysis**, **benchmarking**, **developing patents**, and **providing a means for international companies to find UK business partners**. We first

describe the HUB database (the impact pathway), and then present impact usage data and testimonials (note that confidentiality largely restricted companies sharing financial information).

The impact pathway – the HUB database and search engine

The HUB database went live in July 2015 and includes extensive information on businesses operating in the UK composites sector. The HUB database fields and search facilities were informed by Dr Coronado Mondragon's underpinning research (R1 to R3, Section 2). For each business in the database, the HUB database supports sophisticated search options on whether the business uses, produces, or distributes the following: materials (60 types), equipment/software (100 types), semi-finished materials (30 types), production processes (40 types), services provided (8 types), geographical location and proximity (see source E1, Section 5, for a detailed overview). Figure 1 presents two screenshots to illustrate the HUB website. The outcome of a search includes extensive profiles of relevant businesses, key contacts information, firm memberships, specialisms and the markets it serves. Dr Coronado Mondragon promoted the HUB database to potential users through LinkedIn articles and industry exhibitions/events (E6), such as Composites UK annual conferences.

Figure 1. Example screenshots taken from HUB database and search engine



1. Increasing capacity of UK composites companies nationally and internationally

The HUB was one outcome of the Composites Innovation Cluster consortium, a GBP 22,000,000 research and development programme in the UK. The Hub database enabled the composites industry to build stronger UK supply chains between materials, design, equipment and manufacturing companies: “[text removed for publication]” ([text removed for publication], Cranfield University, E7). The HUB database is the first comprehensive database created exclusively for the needs of the UK’s composite materials sector in the UK and has become the major directory: “[text removed for publication]”. (Composites UK, E2).

At the conclusion of the project in July 2016, 206 companies were registered in the HUB database. By February 2020 the HUB database includes more than [text removed for publication] companies in the composites sector, growing [text removed for publication] in the previous year and currently covering [text removed for publication] of all UK composite companies (Composites UK, E2).

The HUB database benefits UK composite companies through providing a better understanding of the industry and an ability to search the database across an extensive set of fields. It enables users to: “[text removed for publication]” (Composites UK, E2).

Composites businesses which specialize in supporting manufacturing and engineering, reporting the HUB as a powerful tool to understand the composites materials market. The [text removed for publication] of Avalon Consultancy states that it: "...[text removed for publication]" (E4). Cristex (E3), one of the UK's leading suppliers of fibers and fabrics for the UK composites markets, use the HUB database two to five times per month *"for competitor analysis. We extract from information from the database and use it for marketing purposes. Specifically, to find new potential customers to target and market to"* (Marketing Executive, Cristex, E3).

The HUB database has benefitted UK composite businesses by providing a means for **international companies** to find research partners, and raising the visibility of UK firms internationally. Otto Fuchs, a world leader in manufacturing high performance metal forging for aerospace and automotive sectors, sought a UK location for a new composite manufacturing factory (252 workers and GBP100,000,000 sterling investment) and target sales of GBP100,000,000 sterling per year by 2025: "[text removed for publication]." (March 2020, [text removed for publication], Otto Fuchs, E8). Airbus cancelled the nose landing wheel project due to Covid-19 (March 2021, E8), but it was extensively tested by Otto Fuchs who found it feasible and innovative; it is made from lighter composite materials means that the plane's landing gear weighs less, and less weight translates into lower emissions and longer flight range.

Composites UK and Avalon Consultancy endorse the benefits of the HUB to UK composite companies through facilitating **international links** "[text removed for publication]." (Composites UK, E2).

"[text removed for publication]" ([text removed for publication] of Avalon Consultancy, E4).

2. Building Capacity and improving industrial collaboration and product development

The HUB Database has benefitted industry collaboration and patent development among parties developing new products related to fibre-reinforced polymer composites. A [text removed for publication] at the School of Engineering and Technology, University of Hertfordshire testified: "...[text removed for publication]" ([text removed for publication], University of Hertfordshire, E5).

The HUB database's is described to foster collaborative research by an [text removed for publication] at Cranfield (E7): "[text removed for publication]". More specifically, the industry consultant used the HUB to find a company to build a wet compression moulding tool, where this tool led the industry consultant to validate a new composite manufacturing process to be used by the product developer's partners GKN and Nissan to make structures for serial automotive applications.

3. Improving the functioning of 'Composites UK' – the trade body for the UK composites industry

The HUB database has helped the national trade body improve its business functioning. It has advanced its mission to grow the composite sector in the UK: "[text removed for publication]" (Composites UK, E2).

5. Sources to corroborate the impact

E1. Overview of the HUB database (<https://compositesuk.co.uk/hub>). APDF document providing an overview of the HUB, its content and search facilities.

E2. Testimonial from the [text removed for publication], Composites UK, February 2020. Composites UK is the trade body for the UK composites industry.

E3. Structured interview with the Marketing Executive, Cristex, at Composites UK Annual Conference 2019. Cristex is one of the UK's leading suppliers of fibres and fabrics for the UK composites markets.

- E4.** Testimonial from the [text removed for publication], Avalon Consultancy Services, February 2020. Avalon Consultancy specializes in supporting manufacturing and engineering businesses, nationally and internationally.
- E5.** Testimonial from a [text removed for publication], School of Engineering and Technology, University of Hertfordshire.
- E6.** Dr Coronado Mondragon's presentations at Composites UK conferences, 2015, 2016, and LinkedIn articles 2015-2016 to promote the HUB database.
- E7.** Testimonials from an [text removed for publication], School of Aerospace Transport and Manufacturing, Cranfield University, May 2020, March 2021 (note all impact confirmed prior to 31 December 2020 REF deadline).
- E8.** Testimonials from [text removed for publication], Otto Fuchs KG, Germany, March 2020, March 2021 (note all impact confirmed prior to 31 December 2020 REF deadline). Otto Fuchs is a world leader in manufacturing high performance metal forging for aerospace and automotive sectors, employing 9,700 workers and realizing 3bn sterling of sales.