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| <b>Institution: University of Derby</b>   |  |  |
| <b>Unit of Assessment: 17</b>   |  |  |
| <b>Title of case study: Implementing 'green-lean' to achieve operational excellence in transportation logistics and manufacturing.</b>  |  |  |
| <b>Period when the underpinning research was undertaken: 2012–2020</b>  |  |  |
| <b>Details of staff conducting the underpinning research from the submitting unit:</b>  |  |  |
| <b>Name(s):</b>   | <b>Role(s) (e.g. job title):</b>   | <b>Period(s) employed by submitting HEI:</b> |
| Jose Arturo Garza Reyes   | Professor of Operations Management and Head of the Centre for Supply Chain Improvement | 2013–present                                 |
| Anthony Anosike   | Senior Lecturer in Supply Chain Management   | 2012–present                                 |
| Simon Peter Nadeem  | Lecturer in Operations and Supply Chain Management                                     | 2019–present                                 |
| Tracey Wond   | Senior Lecturer in Business Management and HRM   | 2013–2020                                    |
| <b>Period when the claimed impact occurred: August 2013–July 2020</b>   |  |  |
| <b>Is this case study continued from a case study submitted in 2014? No</b>   |  |  |
| <b>1. Summary of the impact</b> (indicative maximum 100 words)  |  |  |
| <p>Green-lean and lean logistics research by the University of Derby's Centre for Supply Chain Improvement (CSCI) (Garza-Reyes; Anosike; Nadeem) has addressed productivity and environmental challenges in distribution activities in the logistics, manufacturing and emergency medical service industries. CSCI's research and engagement with non-profit and private organisations, both nationally and internationally, including companies from Mexico, China, Thailand, Colombia and Oman, has principally generated management and environmental impacts, including:</p> <ul style="list-style-type: none"> <li>(a) changed approaches to the management of resources;</li> <li>(b) improved service delivery and productivity;</li> <li>(c) enhanced processes and reduction of inefficient process;</li> <li>(d) improved environmental performance;</li> <li>(e) informed professional and educational exchanges.</li> </ul> |  |  |
| <b>2. Underpinning research</b> (indicative maximum 500 words)  |  |  |
| <p>The underpinning research comprises work produced by the Centre of Supply Chain Improvement (CSCI) since 2013. The wider body of work includes over 50 journal papers, 19 conference papers, and 7 projects, funded by the British Council, British Academy, Innovate UK, and the Mexican Council of Science and Technology (Consejo Nacional de Ciencia y Tecnología - CONACYT), as well as private sector partners. The research relates to the development and application of lean production principles into new contexts and addresses growing environmental concerns.</p> <p>It began with Garza-Reyes' research recognising that lean could be adopted in logistics contexts to generate efficiencies, eliminate wastes and improve the environmental impact of organisations,</p>  |  |  |

contributing significantly to the notions of *green-lean* and *lean logistics*. Road transportation emerged as a particular focus for Garza-Reyes' research, not least as it has attracted attention for being ecologically/environmentally detrimental. The research addresses important global and national challenges, particularly surrounding environmental and productivity priorities established by the UK's Industrial Strategy and the United Nations Sustainable Development Goals, e.g. Decent Work and Economic Growth (Goal 8), Sustainable Cities and Communities (Goal 11) and Climate Action (Goal 13).

A comprehensive systematic literature review [3.1], conducted by Garza-Reyes unveiled a conceptual and empirical gap in the consolidation of lean principles despite the mounting green agenda. This gap was pronounced within the road transportation context. This research acted as a catalyst for the green-lean and lean logistics movements. Developing this research agenda, Garza-Reyes [3.2], developed a systematic framework, based on a case study approach, with industry partners in Mexico (and funded by the British Council [G3.1] and British Academy [G3.2]). This extended a leading model (Villareal, 2012) of 'Transportation Value Stream Mapping' (TVSM) to consider environmental wastes and the particular characteristics of specialised logistics operations, e.g. ambulance/emergency medical services. Through published research [3.3], Garza-Reyes introduced the notion of 'Sustainable Transportation Value Stream Mapping' (STVSM). This identified particular environmental wastes relevant to the transportation context, and Ambulance Transportation Value Stream Mapping (A-TVSM) [3.4] (theorising from the case study data).

The application of STVSM into various world-leading organisations [3.3] has resulted in improving performance efficiencies, e.g. productivity, administrative availability, clients served, quality (reduction of returns, clients not served); reducing distance, fill losses, labour time and CO<sub>2</sub> emissions. This created confidence in the further development of this research area and underpinned funded projects, led by Garza-Reyes and Anosike, into other contexts (agriculture) [G3.3]. More recently, CSCI's work developed into the emergency medical services (EMS) transportation (i.e. ambulance) context where Garza-Reyes identified that, whilst lean was well adopted in healthcare, it had not been in an EMS transportation context [3.4]. The work has also been applied in Fast Moving Consumer Goods settings [3.5]. Approaches to identifying relevant wastes and piloting their implementation in a process of co-design with stakeholders were identified [G3.4].

The underpinning research and wider body of research have not only refined the green-lean concept but resulted in a pioneering green-lean toolkit that, through a process of applied research, has been iteratively developed and implemented in a range of organisations.

### 3. References to the research (indicative maximum of six references)

#### Peer-reviewed journal articles

University of Derby researchers are indicated by black, underlined text:

**[3.1]** Garza-Reyes, J.A. (2015) 'Lean and Green - A Systematic Review of the State of the Art Literature', *Journal of Cleaner Production*, 102, 18-29.

DOI: <https://doi.org/10.1016/j.jclepro.2015.04.064>

**[3.2]** Villarreal, B., Garza-Reyes, J.A. and Kumar, V. (2016) 'Lean road transportation – a systematic method for the improvement of road transport operations', *Production Planning & Control*, 27(1), 865-877. DOI: <https://doi.org/10.1080/09537287.2016.1152405>

**[3.3]** Garza-Reyes, J.A., Villarreal, B., Kumar, V. and Molina Ruiz, P. (2016) 'Lean and green in the transport and logistics sector – a case study of simultaneous deployment', *Production Planning & Control*, 27(15), 1221-1232. DOI: <http://dx.doi.org/10.1080/09537287.2016.1197436>

## Impact case study (REF3)

**[3.4]** Villarreal, B., Garza-Reyes, J.A., Granda-Gutiérrez, E., Kumar, V. and Lankenau-Delgado, S. (2018) 'A Lean transportation approach for improving emergency medical operations', *Production Planning & Control*, 29(11), 928-942.

DOI: <https://doi.org/10.1080/09537287.2018.1494343>

**[3.5]** Udokporo, C., Anosike, A., Lim, M., Nadeem, S.P., Garza-Reyes, J.A. and Ogbuka, C.P. (2020) 'Impact of Lean, Agile and Green (LAG) on business competitiveness: An empirical study of fast moving consumer goods businesses', *Resources, Conservation & Recycling*, 156, 104714. DOI: <https://doi.org/10.1016/j.resconrec.2020.104714>

### Peer-reviewed funding and grants

**[G3.1]** Garza-Reyes, J.A. and research partners at the Instituto Politecnico Nacional, ESCA Santo Tomas (Mexico), 'Managing Business Excellence and Adapting Innovation Systems for Supporting a Sustainable Transition towards a Low Carbon Economy', British Council and National Council of Science and Technology (Mexico) (Researcher Links), 2014–2015, GBP30,000.

**[G3.2]** Garza-Reyes, J.A. and research partners at the Instituto Politecnico Nacional, ESCA Santo Tomas (Mexico), 'Adoption of Green Technologies and Sustainability Standards for Emerging Economies: The Case of Mexico', British Academy (Newton Advanced Fellowships), 2017–2021, GBP101,700. Total grant of GBP101.700 received and administered by the UoD of which GBP7,500 was allocated to UoD.

**[G3.3]** Garza-Reyes, J.A., Anosike, A., Wond, T. and research partners at the Universidad Autonoma de Aguascalientes (UAA) (Mexico), 'Developing Food Security and Water Conservation for Economic Growth in Mexico – A Smart Monitoring and Control System (SMCS) Agro-Technology for Sustainable and Efficient Farming Operations', British Council and National Council of Science and Technology (Mexico) (Institutional Links), 2017-2018, GBP80,000.

**[G3.4]** Garza-Reyes, J.A. and research partners at the Universidad Autonoma de Aguascalientes (UAA) (Mexico), 'Sustainable Development - Exploring Energy Efficiency Opportunities through Supply Chain and Operations Innovation', British Council (Researcher Links), 2015-2016, GBP46,200.

## 4. Details of the impact (indicative maximum 750 words)

### Environmental, practitioner and organisational impact in road transport logistics

The development of the STVSM by Garza-Reyes and his guided implementation in several private sector companies has led to environmental, practitioner and organisational impact in the UK and internationally. In OXXO FEMSA, which is the largest chain of convenience stores in Latin America with over 18,000 stores, Garza-Reyes' research [3.2] led to sustainable indicators being introduced and, under the guidance of Garza-Reyes, the re-engineering of truck routing processes. This resulted in 'distance travelled in excess' reducing to nil, fill loss reducing from 71% to 54.9%, and a 40% reduction of trucks needed to serve daily demand. This also resulted in non-environmental improvements, including 40% reduction in transport operation costs and serving time from circa 41 minutes to 18.7 minutes [5.1, 5.2].

By utilising the STVSM framework, in DHL Transport Operations (Monterey, Mexico), Garza-Reyes' and his research partners reduced excess distance by 57%, resulting in secondary environmental impacts (such as the reduction of harmful gas emissions) [3.3]. Under the guidance and supervision of Garza-Reyes, his postgraduate students Mr Litao Lou, Mrs Khemchira Kaitwatcharachai and Mr Krishna Balaji and companies' employees respectively applied the STVSM framework at: (1) HPF Co., Ltd., one of the most well-known medium size 3PL companies in Shenzhen, China; (2) ThailandPost Distribution Co., Ltd., a full-service transportation and distribution provider and affiliate of the Thai Post Company Limited (Thailand Post); and (3)

Chandra Transports, a traditional third-party logistics service provider operating in Tamil Nadu, India. As an example of impact on practitioners or future practitioners through pedagogy, Garza-Reyes' students benefitted from his innovative green-lean, applied pedagogic practice, gaining valuable practical experience through adapting the STVSM framework to solve real business problems. Indeed, in the three cases, STVSM helped the companies in identifying wastes and inefficiencies in their logistics processes, which consequently allowed them to change their practices accordingly to reduce costs and become more competitive [5.3, 5.4, 5.5].

### **Practitioner and health impacts in ambulance settings**

Working with Cruz Roja Mexicana (Mexico's Red Cross) in two separate projects, CSCI was able to apply its research on lean logistics and, in particular, sustainable (STVSM) and ambulance transportation value stream mapping (A-TVSM) [3.4], directly into the emergency medical context.

Project 1 focused on improving efficiency/agility and through the guided application of Garza-Reyes' research toolkit, the organisation saw improved ambulance response times (response times within ten minutes increased from 16.4% to 58% post-intervention). Further, ambulance turnaround times increased by 34%, increasing services from 4 to 6 per 8-hour shift (i.e. creating capacity for two additional services in each shift) [5.6].

Project 2 focused on improving ambulance capacity by using lean principles and adopting the Theory of Constraints. With this knowledge and Garza-Reyes' methodology, ambulance operations were re-routed following a facilitated process with internal stakeholders. Wastes such as over-processing time were identified in facilitated sessions. As a result, a reduction of ambulance cycle and turnaround times by about 50 min/service was achieved, increasing ambulance capacity from 4 to a maximum of 6 services per shift. Additionally, emergency call coverage within 10 minutes increased from 37% to 85% and response time decreased by 10 min on average. This further increased the number of services per ambulance per shift from 6 to 7 [5.7, pg. 269]. These improved efficiencies created better outcomes for the delivery of emergency care with patients being able to access it and receive an enhanced experience.

### **Extending the impact reach beyond road transportation**

In 2016, CSCI recontextualised its research into a slightly different context – agriculture. Garza-Reyes led a British Council Institutional Links project in farming settings in Mexico [G3.3]. Whilst the project was multi-faceted, CSCI delivered best practice exchanges and workshops to local businesses, universities and government organisations in Mexico, where delegates were trained on the green-lean principles [5.8]. The project aimed to address outcomes relating to poverty and food security.

The commercial impact created by CSCI's research is further demonstrated by its work with academic and industry partners in an iron ore shipping context in Oman. Working with a leading shipping company who had incurred GBP1m+ penalties/demurrage fees, CSCI was able to develop and apply a lean framework which led to the reduction in commercial time (a saving in excess of 30%) and the reduction in demurrage fees by approximately USD300,000 [5.9, pg. 1092; 1096; 1108].

### **Practitioner and professional impacts through executive education**

The research has also been used in a host of educational exchanges with professional and practitioner groups including professional bodies. CSCI's research has led to its engagement with the Chartered Institute of Logistics and Transport (CILT) and its Logistics Research Network (LRN), and CSCI hosting and chairing CILT's LRN conference in 2016. The research has gained the attention of the CILT in the UK and work is currently underway to embed the research in their resources.

**5. Sources to corroborate the impact** (indicative maximum of 10 references)

**[5.1]** English language testimonial from OXXO FEMSA provided by the Demand Planning (Planeacion de la Demanda) Manager on 21 February 2020 which confirms the improvements.

**[5.2]** OXXO FEMSA system data (2015–2016) and letter in English (21 February 2020) from OXXO FEMSA Demand Planning Manager which validates the data.

**[5.3]** English language testimonial from HPF Co., Ltd. provided by the Vice-General Manager on 26 February 2020.

**[5.4]** English language testimonial from ThailandPost Distribution Co., Ltd. provided by the Operating Staff Manager on 6 July 2020.

**[5.5]** English language testimonial from Chandra Transport provided by the Operations Director on 27 September 2020.

**[5.6]** English language testimonial from the Mexican Red Cross provided by the General Director on 11 February 2020.

**[5.7]** Data published in an academic output: Garza-Reyes, J.A., Villarreal, B., Kumar, V., Diaz-Ramirez, J. (2019) 'A Lean-TOC Approach for Improving Emergency Medical Services (EMS) Transport and Logistics Operations', *International Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management*, 22(3), 253-272.  
DOI: <https://doi.org/10.1080/13675567.2018.1513997> (page 269).

**[5.8]** Group of press releases and articles about the Institutional Links project:

- a) Press release, Autonomous University of Aguascalientes (2016).
- b) Newspaper article, *La Jornada* (25-06-2016).
- c) Practitioner magazine article, *Lider* (12-06-2017).
- d) Blog, *Aguaardiente* (n.d.).
- e) Blog, *El Clarinete* (24-05-2016).
- f) Blog, *La Jornada* (27-03-2017).

These documents were originally published in Spanish. The original documents can be provided to REF 2021 in Spanish, with accompanying English translations.

**[5.9]** Data published in an academic output: Garza-Reyes, J.A., Al-Balushi, M., Antony, J., Kumar, V. (2016) 'A Lean Six Sigma framework for the reduction of ship loading commercial time in the Iron Ore Pelletising industry', *Production Planning & Control*, 27(13), 1092-1111.  
DOI: <http://dx.doi.org/10.1080/09537287.2016.1185188> (pages 1092; 1096; 1108).