

# **A Waste to 3D Printing: the Development of Additive Symbiotic Networks**

**Inês A. Ferreira**

PhD Student

Department of Mechanical & Industrial Engineering

NOVA School of Science and Technology

Caparica, Portugal

[id.ferreira@campus.fct.unl.pt](mailto:id.ferreira@campus.fct.unl.pt)

**Helena Carvalho**

Associate Professor

Industrial and Management Engineering

UNIDEMI – Department of Mechanical and Industrial Engineering, NOVA School of

Science and Technology

2829-519 Caparica, Portugal

[hmlc@fct.unl.pt](mailto:hmlc@fct.unl.pt)

## **Abstract**

Industry 4.0 technologies, such as additive manufacturing (AM) and blockchain technology, may drive the implementation of a new generation of circular economy strategies. However, the role of these new technologies in designing and implementing circular economy ecosystems is not a trivial issue. In this sense, this PhD research work intended to foster knowledge for the development of industrial symbiosis networks within the AM industry - the so-called additive symbiotic networks. A systematic literature review was performed and revealed current circular economy relationships within the AM industry and highlighted the potential of this industry to create and develop additive symbiotic networks, in plastic wastes from other industries may be used as material inputs for AM processes. A definition of the concept additive symbiotic networks is proposed in this work.

Nevertheless, given the digital nature of AM and considering challenges related to trust or the implementation of transactions within the additive symbiotic networks, there is a need to find tools that enable the development of those networks. Blockchain technology may be an enabler of such symbiotic networks, and its adoption within these settings may have implications in the supply chain of additive symbiotic networks. Using an abductive research approach, in this work two case studies were conducted concerning two additive symbiotic networks, that comprised companies using AM processes to valorize plastic waste streams. Case study A highlighted that there is potential within the context of additive symbiotic networks to explore the adoption of blockchain technology and identified a set of requirements that support the technology adoption in that specific network context. From these conclusions, case study B was developed to understand the implications of adopting such disruptive technology as the blockchain in the supply chain structure of an additive symbiotic network. Results showed that with the adoption of blockchain there is a reduction in the number of intermediary stakeholders involved in the network and there is an adaptation of the value flows within the network.

By offering a tool that helps to deal with the challenges associated with the additive symbiotic networks, exploring its adoption and some of its implications in the supply chain of those networks, this PhD work encourages the development of the additive symbiotic networks, contributing to the efficient use of natural resources, promoting the collaboration between industries, and reducing waste streams to achieve more sustainable production.

## **Keywords**

Additive symbiotic networks, Blockchain technology, Supply chain structure, Circular economy and Additive manufacturing.

### **Acknowledgements**

Inês A. Ferreira acknowledges financial support from Fundação para a Ciência e Tecnologia (FCT) for funding PhD Grant - REF: SFRH/BD/145448/2019. Helena Carvalho acknowledges Fundação para a Ciência e a Tecnologia (FCT-MCTES) for its financial support via the project UIDB/00667/2020 (UNIDEMI).

### **Biography**

**Inês A. Ferreira** just recently presented her PhD Thesis on the topics of Industrial Symbiosis in the Additive Manufacturing industry and the adoption of blockchain technology as a tool to promote those networks. This work was realized within the Doctoral Program of Industrial Engineering at NOVA School of Science and Technology. She started her PhD in 2019, after she delivered her Master Thesis in Industrial and Management Engineering, focusing on the topic of Industrial Symbiosis Network in the Portuguese Pulp, Paper and Carboard Industry. From 2019 until 2020 she has been invited as Invited Assistant Professor in Stock's Management classes at NOVA School of Science and Technology. Moreover, she is currently working as an Invited Auxiliar Professor at ISEG (Lisbon School of Economics & Management), in the classes of Production and Operation Management. Her research interests mainly concern sustainability, circular economy, industrial symbiosis networks and supply chain management.

**Helena Carvalho** is an Associate Professor in the Department of Mechanical and Industrial Engineering at the NOVA School of Science and Technology, Portugal. She is a physics engineer and holds an MSc in Industrial Engineering, both degrees from Universidade Nova de Lisboa. At the end of 2012, she completed her PhD in Industrial Engineering at the Universidade Nova de Lisboa, where she undertook research in supply chain resilience. She is the coordinator of the Master in Maritime Logistics. She lectures several courses on topics related to industrial engineering, including logistics, quantitative methods, decision models, among others. She is the vice-director of UNIDEMI (R&D Unit in Mechanical and Industrial Engineering). She has a special research interest in the supply chain management topic, namely how to make supply chains and respective organizations more sustainable by deploying lean and green practices and at the same time assuring system resilience. As an extension of these research topics, currently, she is developing research on eco-efficiency and eco-innovation subjects.