Analysis of the embodied carbon emissions flows in China: applying a network perspective to sectors, provinces, and carbon communities within the Chinese economy

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Doctor of Philosophy

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Li Huang declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Institute for Sustainable Futures at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of the requirements for a degree at any other academic institution except as fully acknowledged within the text. This thesis is the result of a Collaborative Doctoral Research Degree program with Shanghai University.

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THESIS FORMAT STATEMENT

This thesis takes the format of thesis by compilation. It is structured as a single manuscript that comprises a combination of three chapters and two published papers.

The paper *a systematic review of empirical methods for modelling sectoral carbon emissions in China* published in the *Journal of Cleaner Production* is directly used in Chapter 2 to provide a literature review of the research field.

The paper *carbon communities and hotspots for carbon emissions reduction in China* is published in the journal *Sustainablity* and is directly used in Chapter 3 for proposing a theoretical model and empirical analysis.

STATEMENT OF CONTRIBUTIONS TO THE PAPERS CONTAINED IN THE THESIS

Statement of Contributions to the Papers contained in this thesis

The following list summarizes Li Huang's particular contributions to the joint papers directly included in this thesis.

Paper	Li's Contribution
Huang, L., Kelly, S., Lv, K., & Giurco, D. (2019). A systematic review of empirical methods for modelling sectoral carbon emissions in China. *Journal of Cleaner Production*, *215*, 1382–1401. https://doi.org/10.3390/su11195508 This paper is directly used in Chapter 2.	Overall 90 %Conceptualization and formal analysis 95% Methodology 90% Data collection 100% Writing-original draft 100%
Huang, L., Kelly, S., Lu, X., Lv, K., Shi, X., & Giurco, D. (2019). Carbon communities and hotspots for carbon emissions reduction in China. *Sustainability*, *11*(19), 5508. https://doi.org/10.1016/j.jclepro.2019.01.058 This paper is directly used in Chapter 3.	Overall 90% Conceptualization and formal analysis 95% Methodology 85% Data collection 100% Writing-original draft 100%

Declaration

Li Huang's percent contributions to the above two papers have been endorsed by all the authors. Permission to include the papers into the thesis has also been granted by all the authors.

For the above two papers, Li Huang completed the original draft writing and analysis independently. Other authors contribute to the papers by having supervision or consultation meetings to improve the paper quality

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Scott Kelly	Production Note: Signature removed prior to publication.	Xunpeng Shi	Production Note: Signature removed prior to publication.
Damien Giurco	Production Note: Signature removed prior to publication.	Xuan Lu	Production Note: Signature removed prior to publication.

Two working paper arises from this thesis

Huang, L., Kelly, S., Lv, K., Xuan L., & Giurco, D. (2020). The structural roles of sectors and their contributions to carbon emissions in China: A complex network perspective.

Lu, X., Kelly, S.,**Huang, L.*** (2020). Evaluating Systemic Credit Risk in China Between the Banking Sector and the Real Economy. submitted

Abstract

With China's commitment to achieve peak emissions by 2030, emissions from different sectors of the economy are being examined. China's current carbon emissions mitigation research focus mainly on the two ends of the industrial supply chain: production and consumption. Most of the intermediate industries between these two ends are presently being overlooked. Research into the ways in which carbon emissions are transferred between sectors can provide a theoretical basis and evidence to identify the key industries and communities to achieve effective emissions mitigation.

This research combines input–output modelling and network analysis to track and examine the transfer of embodied carbon emissions between sectors and regions in China. It develops an embodied carbon emission transfer network model for such a task. In addition, empirical studies are conducted to examine the emissions transfer in China from 2007 to 2012. Network analysis is applied to clarify transmission pathways from macro, meso and micro perspectives. The role played by the structure of sectors and carbon communities are studied using a hierarchical linear model.

Network analysis metrics are used to prioritise which sectors to focus on to reduce future carbon emissions. Sectors with high out-degree, such as the electricity sector, and sectors with high in-degree, such as the construction sector, can act as a focal point for enhancing carbon emissions reduction performance. Sectors with high betweenness, such as the metallurgy sector, are shown to be hubs of the emission network, and can work as leverage points for cutting carbon-intensive inputs and hence reduce total carbon emissions along industrial supply chains.

The identification of carbon communities within which sectors engage in intensive carbon emissions exchange can help provincial governments make decisions about where they can collaborate to obtain synergistic outcomes in reducing carbon

emissions. Sectors within the same community, such as Shanghai-Zhejiang community, can strengthen their cooperation to achieve greater mitigation efficiency. Additionally, for communities which have comparatively low within-community carbon flows, such as Shanxi community, the focus should be on external connections outside the community.

'One community – one policy' is proposed for the carbon emissions mitigation work. A sector's emissions are affected both by its node level and community level structures. Therefore, to reduce the carbon emissions, the sector and its community should be considered together to achieve a synergy. In addition, the increasing size and density of carbon communities due to industrial agglomeration can have a restraining effect on the growth of sectoral carbon emissions.

Keywords: carbon emissions; industry; sector; complex network; input-output analysis; structural characteristics.

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