

Far Flung Forest Landscapes in the Anthropocene

Structural analysis of China's embodied forest network

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OUTLINE

- Intro/Context
- Overview: Analyzing Economic and Ecological Systems
- Landscape Extended Models
- China's Forested Landscapes and Embodied Trade Networks
- Resilience Analysis of China's Forest LE-MRIO
- Conclusions and Future Work
- Acknowledgements

- Ecological studies are now embedded in the anthropocene
- Interconnected world
- Global environmental change
- Complex systems at global scales

Overview

The Anthropocene

- Humans = dominant global impact -> Anthropocene

The “S”-Word

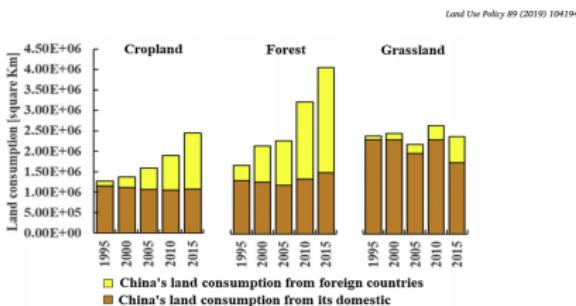
- Indirect effects and The far reach of the city
- Complex systems = many players and indirect effects matter (surprising)

Forests are important!

Forest Images

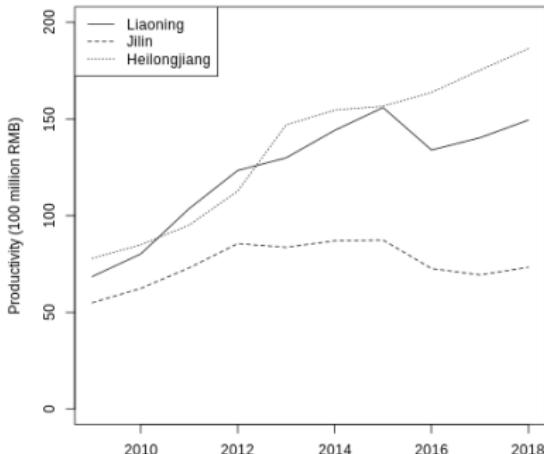
A little money moves a lot of forest.

- Tian et al. 2019 showed that China consumes an equivalent amount of domestic cropland as forest land, on the order of 10^6 km^2 .
- Looking at the domestic landuse productivity data for China, forests have the lowest monetary productivity.
- Thus, per unit monetary output a relatively larger amount of forest land is used.

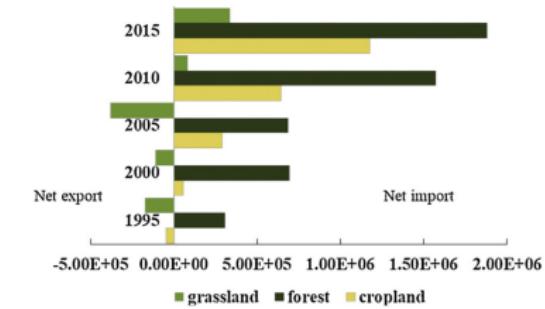


A little money moves a lot of forest.

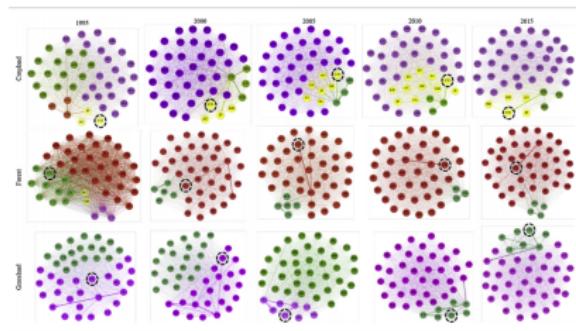
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Global Landuse Trade and China



Global Landuse Trade and China



Background: Economy == Ecology

- Economic trade data is a window into human impacts

Background: Input-Output Models

The Review of Economic Statistics

VOLUME XVIII

AUGUST, 1936

NUMBER 3

QUANTITATIVE INPUT AND OUTPUT RELATIONS IN THE ECONOMIC SYSTEM OF THE UNITED STATES

INTRODUCTION

The statistical study presented in the following pages may be best defined as an attempt to construct, on the basis of available statistical material, a quantitative *Input-Output* of the United States for the year 1935.¹

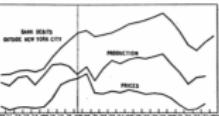
One hundred and fifty years ago, when Quesnay first published his famous schema, his contemporaries and disciples acclaimed it as the greatest "invention" since Newton's laws. The idea of general interdependence existing among the various parts of the economic system has become by now the very foundation of economic analysis. Yet when one considers the exacting application of this theoretical tool, modern economists must rely exactly as Quesnay did upon fictitious numerical examples. What would be the present state of the theory and policy of international trade if, instead of actual balances of foreign trade, the economist had to base his analysis upon assumed numerical set-ups supplemented by scattered items of actual statistical information? This is the situation in which the author of economic theory found himself when he faced a problem of national production, consumption, and distribution. Despite the remarkable increase in the volume of primary statistical data, the proverbial boxes of theoretical assumptions are in this respect as empty as ever. Considerable progress has been achieved in the field of national income statistics. The economic balance of some of the most important branches of the national economy, particularly

The publication of this preliminary survey is prompted by the conviction that the inevitable path of any empirical research is that of trial and error.

Governmental publications constitute the main source of primary statistical information used in this study. Additional data were gathered from trade publications, and in some instances the results of special investigations have been utilized. In many cases, use was made of the work of the National Bureau of Economic Research on national income.

At the time that this study was initiated (1935) the publication of the detailed results of the 1930 Census was still far from complete. As a result, the Census of 1930 had to be used. It is because of this fact that the entire investigation is based on 1930 data.

CHART I.—SERIES INDICATIVE OF BUSINESS CONDITIONS

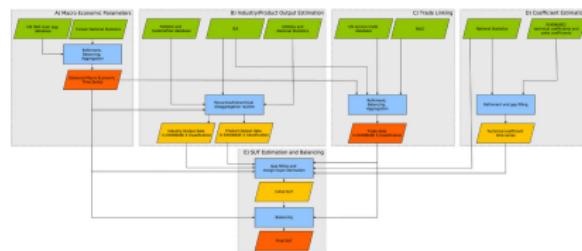


The general business conditions prevailing during that year are described in W. L. Thorp's *Business Annals* in the following terms:

Background: Input-Output Models

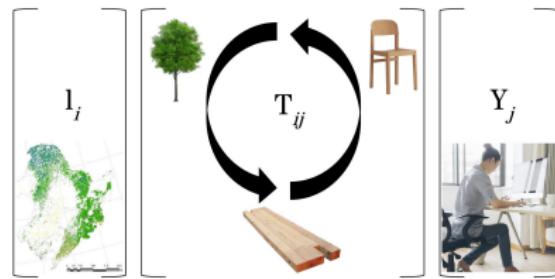
- How do we quantify and manage systems?
- Input-Output Analysis provides a modeling framework
- Direct consumption
- Trade occurs among sectors == Indirect consumption
- IO and MRIO models
- A new equation for a new era in science $E = F(I-A)^{-1}$

Background: Input-Output Models



Background: Environmental Extension

- Allows for indirect/consumption based accounting



Background: Environmental Extension

The diagram illustrates the environmental extension equation:

$$L_j = l_j + T_{ij} \cdot Y_j$$

The components of the equation are represented by icons:

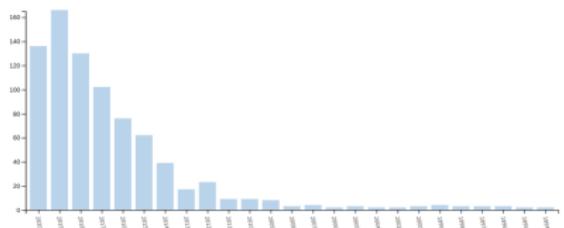
- l_j : Land area used by region j (represented by a landscape image).
- T_{ij} : Total area used for one monetary unit for a sector (represented by a tree icon).
- Y_j : Final consumption (not used to create additional products) (represented by a person working at a desk icon).

A large black arrow points from the T_{ij} term to the Y_j term, indicating the flow of land area used from production to final consumption.

Below the equation, definitions are provided:

- Land area used by region j
- Total area used for one monetary unit for a sector
- Input from one sector used for one unit output of a sector
- Final consumption (not used to create additional products)

wos_mrrio_time.jpg

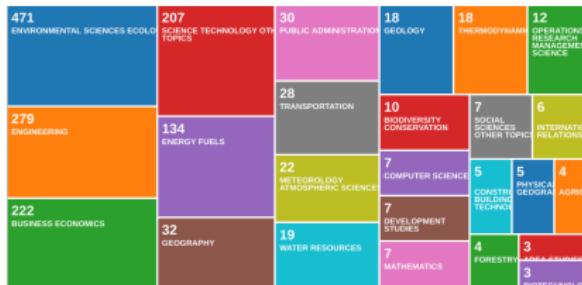


wos_mrío_auth.jpg



wos_mrio_funding.jp





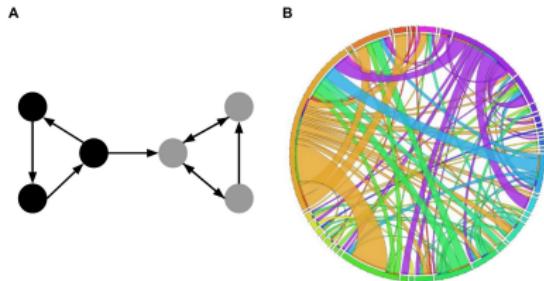
wos_mrio_region.jpg



Background: Networks are Everywhere



Background: Networks are Everywhere



Background: Ecological Network Analysis

- Ecological network theory provides predictions and metrics (Lau 2017)
- Systems theory provides strategies for interventions
- ENA <- Odums, MacArthur, Ulanowicz, Patten,
- SNA -> ecological networks (Watts and Strogatz, etc.)
- Structure linked to function (Donella Meadows)

Which metric?

Why information metrics?

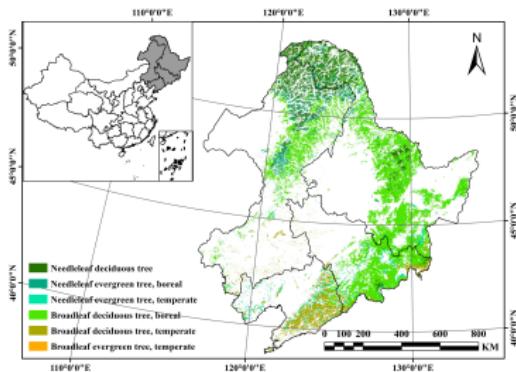
Research: Why Chinese Forests?

- Work = Forest Land Embodied in Trade

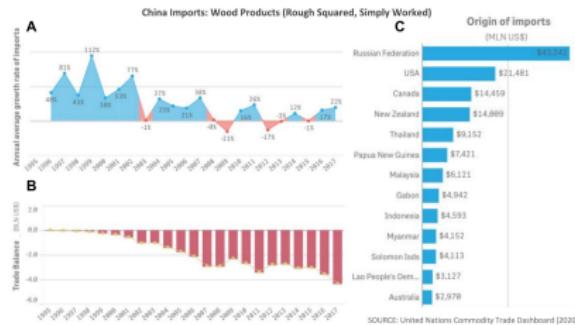
A Brief History of Forest Time in China

- China is big and diverse
- Long history of human habitation in China
- Historically, two primary regions of forestry
- Forest conservation impacts harvest
- Flows within China and among countries globally important

Research: Why Chinese Forests?



Research: Why Chinese Forests?



Methods: Model MRIO_{China}

Table 1
The structure of the ecological MRIO account.

		Intermediate use		Final demand					
		Region 1	Region m	...	Region 1	Region m	
Input	Output	Sector 1	...	Sector n	...	Sector 1	...	Sector n	
		Region 1 Sector 1 ... Sector n	...	Region m Sector 1 ... Sector n	...	Region 1 Sector 1 ... Sector n	...	Region m Sector 1 ... Sector n	
Intermediate inputs in regions		x_{ij}^{ex}		f_i^T					
Primary inputs		p_j^S							
Exogenous environmental inputs		u_j^S							

Methods: Model MRIO_{China}

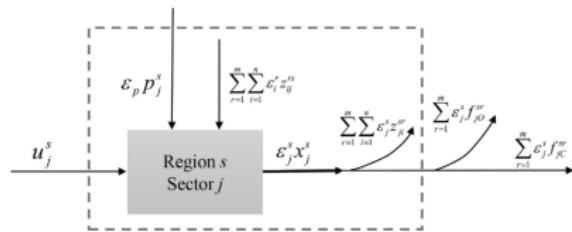
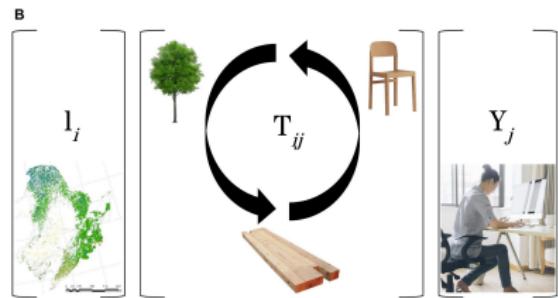


Fig. 2. Resource use flows for Sector j in Region s within the world economy.

Methods: Environmentally Extended Model

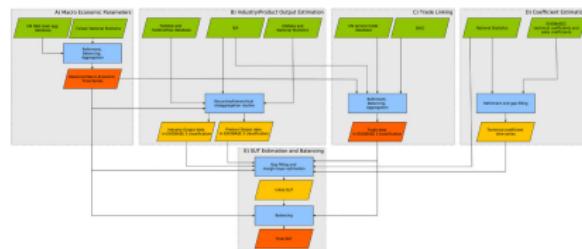
MRIOD_{China}



Methods: Model Source

NEED TO ADD FIGURE WITH DATA FLOWS

Maybe check the Mi 2018 supp mat



Main Focus of Research

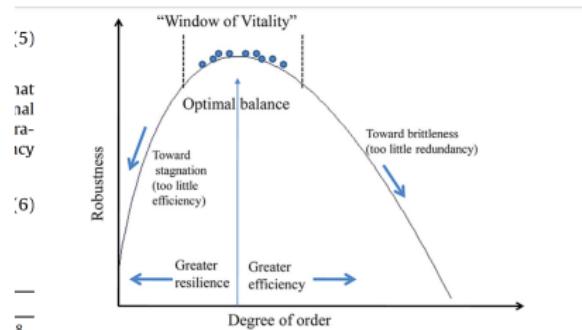
- ① What research has been done on forest or forest landscape embodied networks?
- ② What is the network structure? How can we characterize it?
- ③ What can we say about the potential system dynamics based on network structure?

Research: Network Analysis

- LEMRIO global (Tian 2019)
- LEMRIO local (Chen 2019)
- Your LE-MRIO China
- Your ENA analysis
 - Small world
 - Modularity
 - Centrality
 - Control
 - Resilience

Research: Structural Analysis

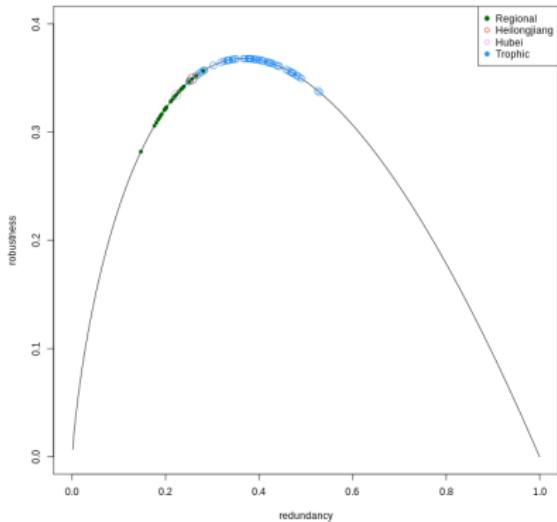
- Analysis = Structure = Robustness



Research: Structural Analysis

- Overly efficient = Brittle
- Overly redundant = Stagnant
- Both can lead to niche openings
- Niches can then be filled by natural selection, adaptation or invasion

Forest Landscape Networks are More Efficient but Less Robust

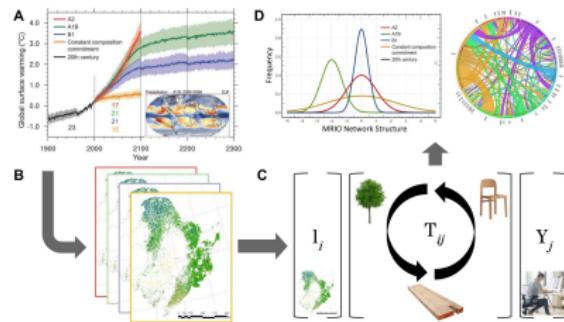


Caveats

- Limitations of MRIO
- Potential impacts of storage lags and buffers

Future: Next up, climate change variability

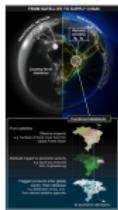
- Next up = Climate change impacts and global scale



Future: Next up, climate change variability



Future Work: Remote Sensing Trade Models



Q & A