Far Flung Forest Landscapes in the Anthropocene

Structural analysis of China's embodied forest network

M.K. Lau (Ph.D.)

Overview

- Intro/Context
  - Forests are globally important
  - Anthropocence effects
  - Global forest loss and gain and change
    - Global greening = India(Agriculture) + China(Forests)
- Economics*Ecology = Landscape Extended Models
- Network Analysis of China's Greening
  - Global Scale
  - Local Scale
    - Landscape = Chen 2019
    - Resilience Analysis of China's Forest LE-MRIO
- Conclusions and Future Work
- Acknowledgements

Forests are Important Globally

- biodiversity
- water and nutrient cycling
- carbon storage
- resources(wood, food)
- culturally

The Anthropocene

- Humans = dominant global impact -> Anthropocene
- Global = Climate Change
- Indirect Effects Significant

In the Anthropocene, Economy is Global Ecology

- Economic trade data is a window into human impacts
- Brief history of IO and ENA analyses
- Global Trade Models
- Trade Networks MRIO = Sectors + Regions
- Environmental Extensions
- Forested Landscapes and Embodied Trade Networks

Interactions/Trade = Complex Systems

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

How do we study forests in this context?

Background: Networks are Everywhere

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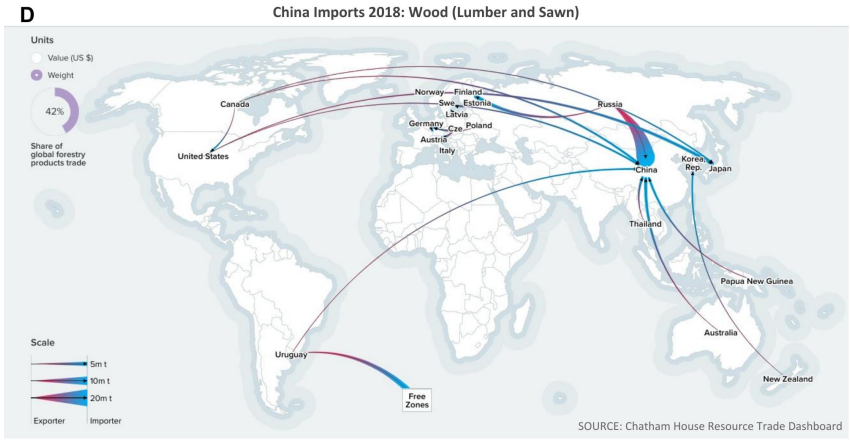

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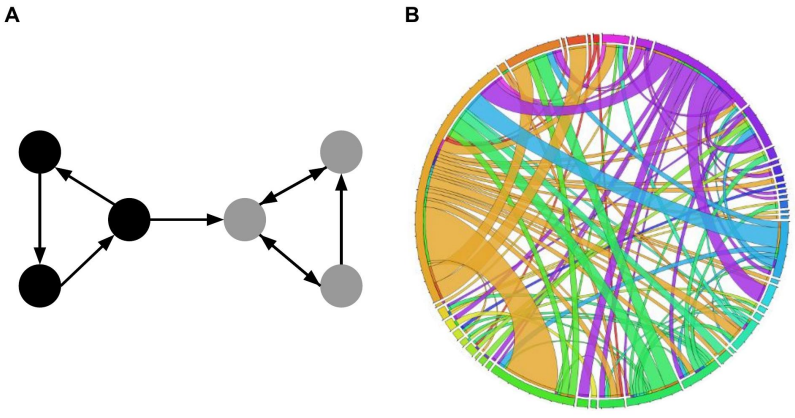


Background: Ecological Network Analysis

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

Research: Why Chinese Forests?

- Work = Forest Land Embodied in Trade

Global forest loss and gain and change

Global greening

Global greening = India(Agriculture) + China(Forests)

- India is greening agriculturally

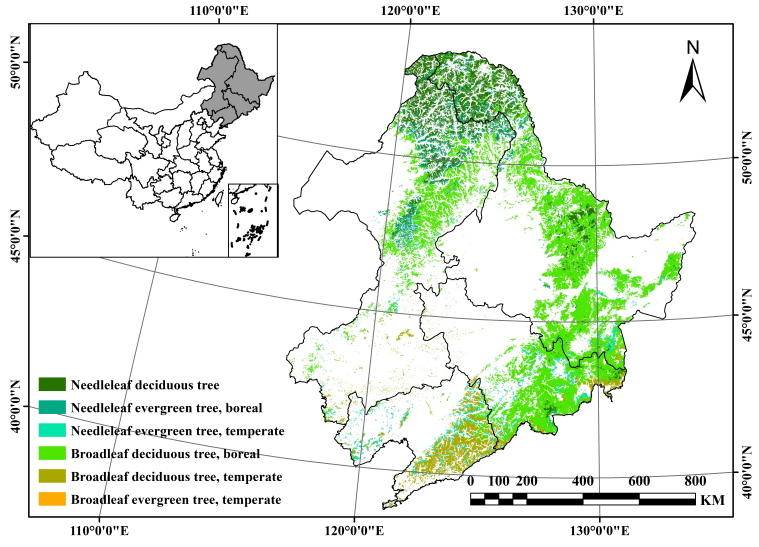
Global greening = India(Agriculture) + China(Forests)

- China is greening through reforestation

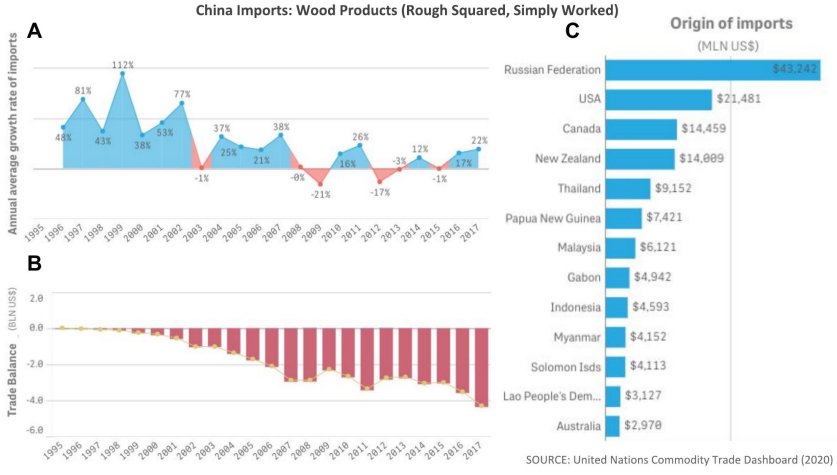
A Brief History of Forest Time in China

- China is big and diverse (Tropical to Alpine/Boreal)
- 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?

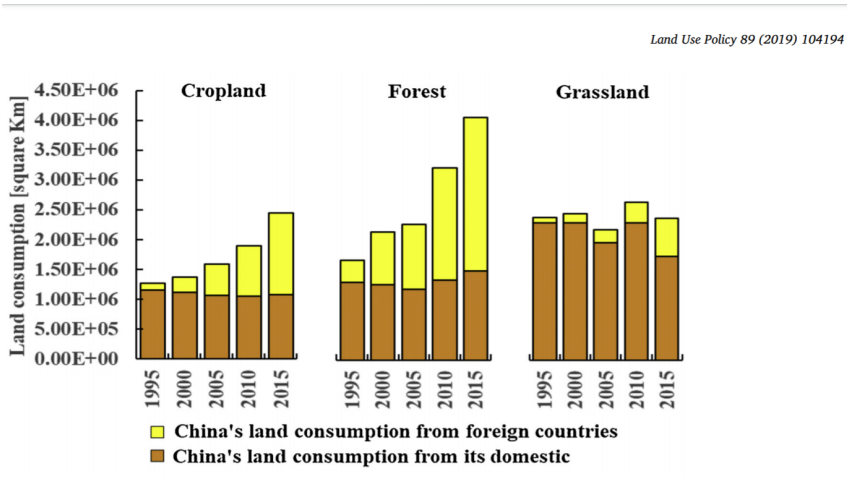


Network Analysis of China's Greening

- Global Scale
- Local Scale
  - Landscape = Chen 2019
  - Resilience Analysis of China's Forest LE-MRIO

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.



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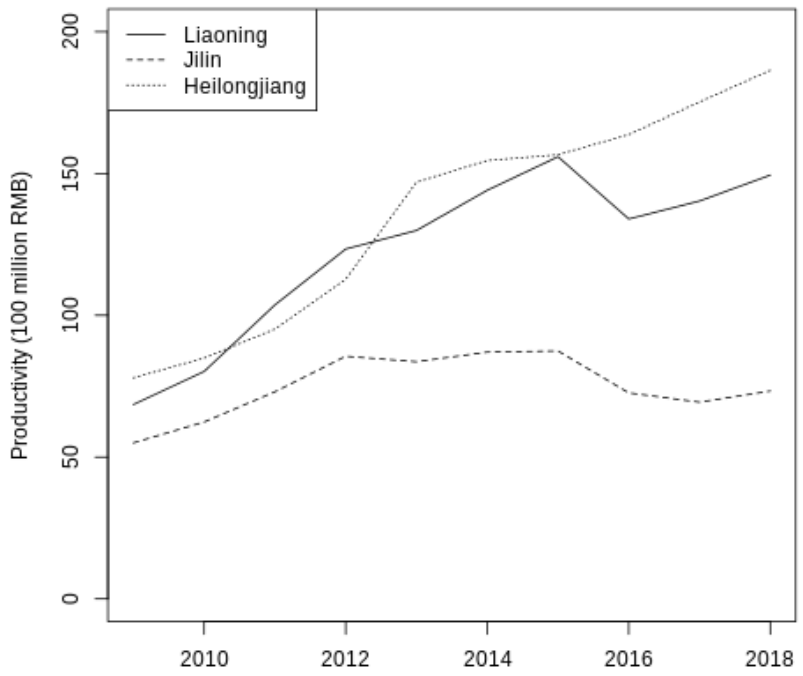
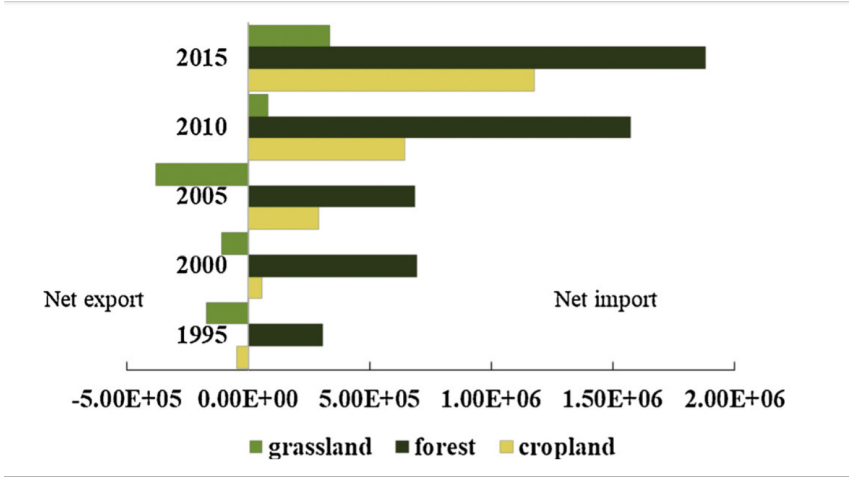


Global Landuse Trade and China



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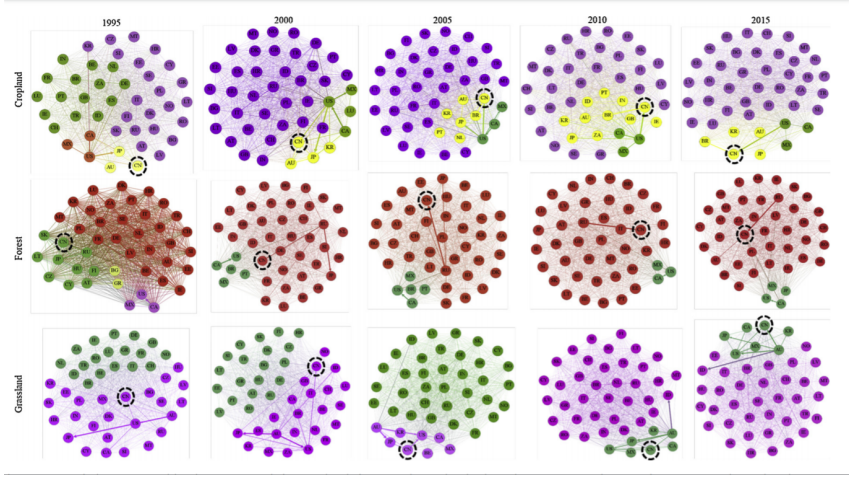


Background: Input-Output Models

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 materials, a *Tableau Economique* of the United States for the year 1919.[1]

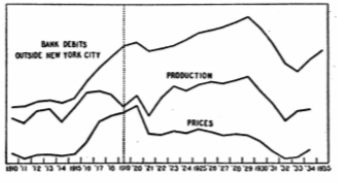
One hundred and fifty years ago, when Quesnay first published his famous schema, his contemporaries and disciples acclaimed it as the greatest "invention" since Newton's laws. The idea of general interdependence existing among the various parts of the economic system has become by now the very foundation of economic analysis. And yet, when it comes to the practical 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 setups, supplemented by scattered items of actual statistical information? This is the situation in which the student of economics finds himself at present when he faces 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 (1932), the publication of the detailed results of the 1929 Census was still far from complete. As a result, the Census of 1919 had to be used. It is because of this fact that the entire investigation is based on 1919 data.

CHART 1.—SERIES INDICATIVE OF BUSINESS CONDITIONS

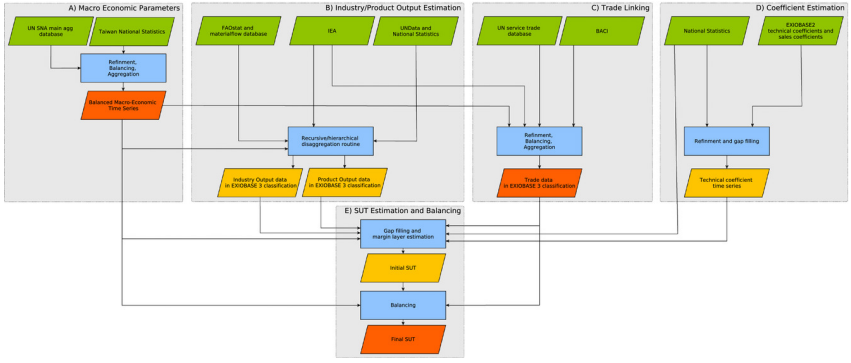


The general business conditions prevailing during that year are described in W. L. Thorp's *Business Annals* in the following terms:

Background: Input-Output Models

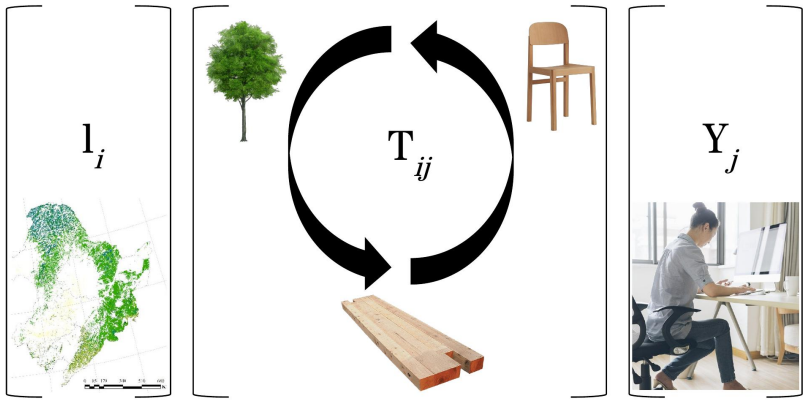
- How do we quantify and manage systems?
- Input-Output Analysis provides a modeling framework
- Direct consumption
- Trade occurs among sectors == Indirect consumption
- IO and MRIO models
- A new equation for a new era in science E = F(I-A)^-1

Background: Input-Output Models

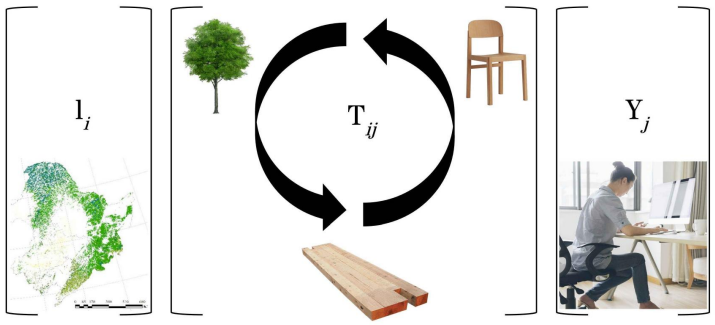


Background: Environmental Extension

- Allows for indirect/consumption based accounting



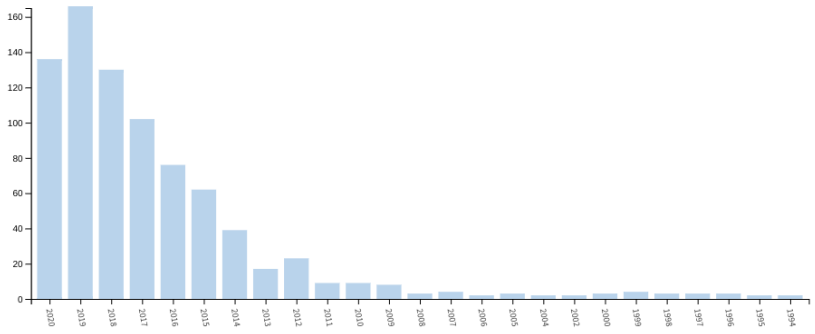
Background: Environmental Extension



$$L_j = l_i \cdot T_{ij} \cdot Y_j$$

- L_j: Land area used by region j
- l_i: Total area used for one monetary unit for a sector
- T_{ij}: Input from one sector used for one unit output of a sector
- Y_j: Final consumption (not used to create additional products)

wos_mrio_time.jpg



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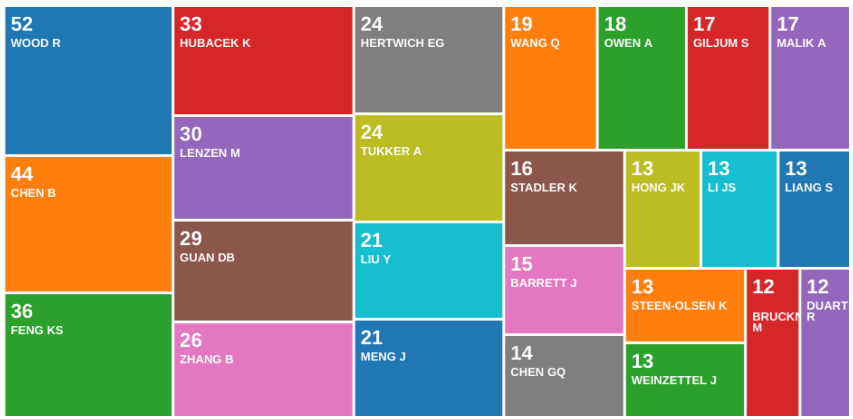

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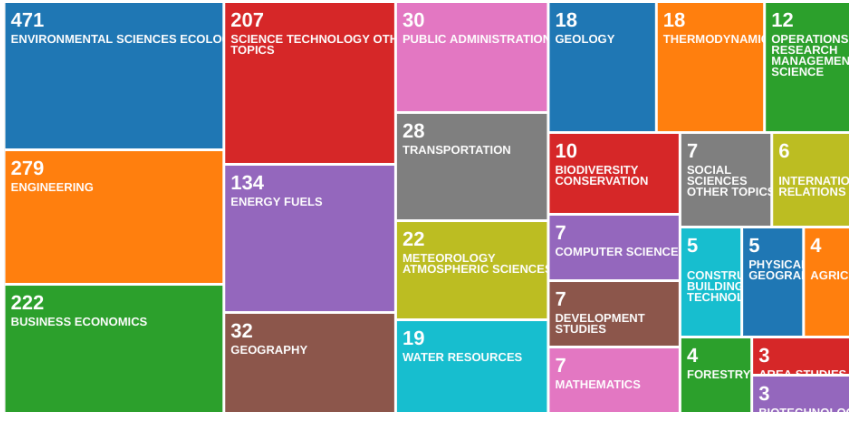
wos_mrio_field.jp



wos_mrio_region.jpg

Which metric?

- Information

Why information metrics?

- Related to Shannon Information/Diversity index
-

$$H = -\sum_{i}^{n} p_i log(p_i)$$

Methods: Model MRIO *China*

Table 1
The structure of the ecological MRIO account.

Input \ Output			Intermediate use							Final demand									
			Region 1			⋯	Region m			Region 1					⋯	Region m				
			Sector1	⋯	Sector n	⋯	Sector1	⋯	Sector n	Household consumption	Non-profit institutions consumption	Government consumption	Rest of final demand (capital goods)	⋯	Household consumption	Non-profit institutions consumption	Government consumption	Rest of final demand (capital goods)	
Intermediate input	Region 1	Sector1	z_{ij}^{rs}							f_i^r									
		⋯																	
		Sector n																	
	⋯																		
	Region m	Sector1																	
		⋯																	
		Sector n																	
Primary inputs			p_j^s																
Exogenous environmental inputs			u_j^s																

Methods: Model MRIO *China*

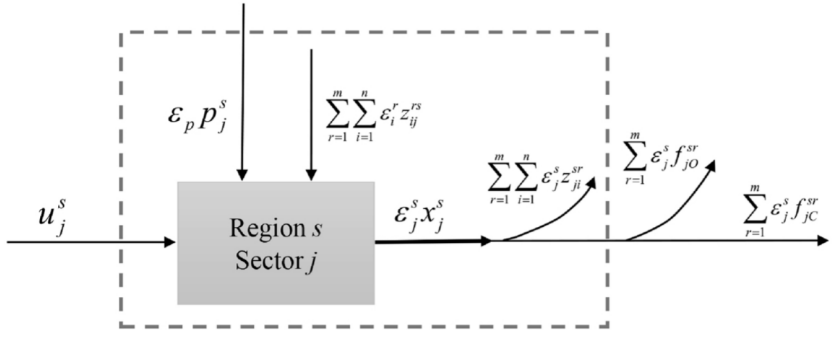
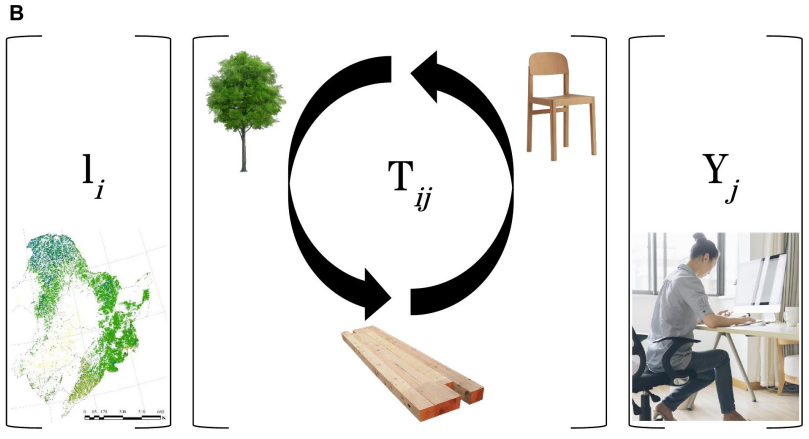


Fig. 2. Resource use flows for Sector j in Region s within the world economy.

Methods: Environmentally Extended Model

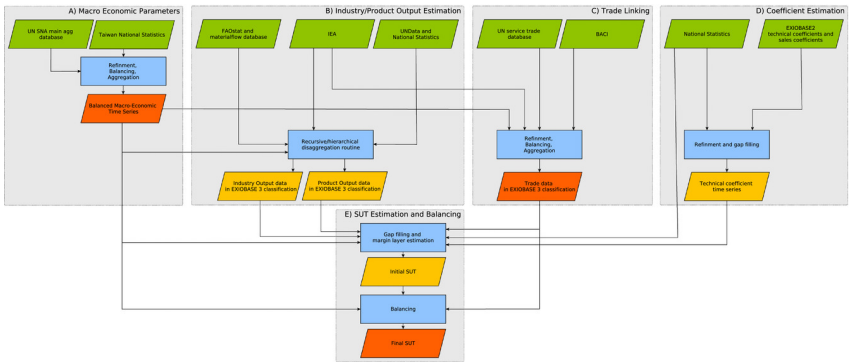
MRIO *China*



Methods: Model Source

NEED TO ADD FIGURE WITH DATA FLOWS

Maybe check the Mi 2018 supp mat



Main Focus of Research

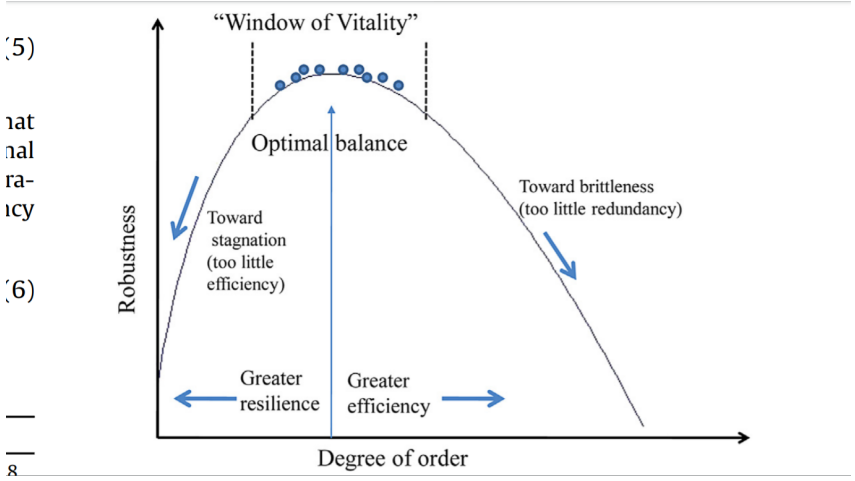
1. What research has been done on forest or forest landscape embodied networks?
2. What is the network structure? How can we characterize it?
3. What can we say about the potential system dynamics based on network structure?

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

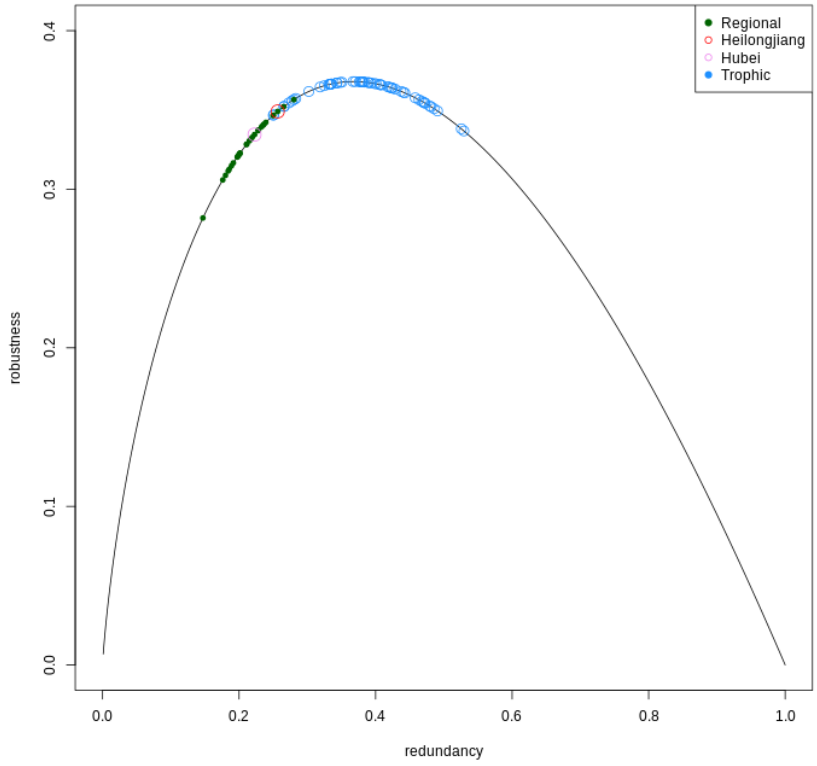
- Analysis = Structure = Robustness



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

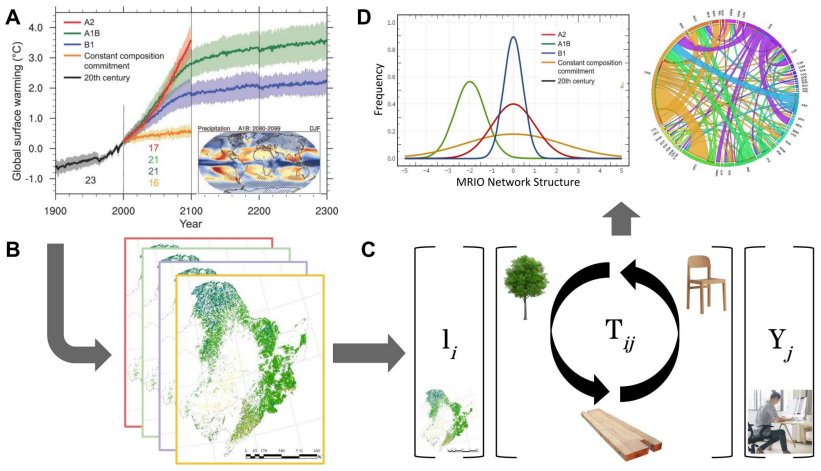


Caveats

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

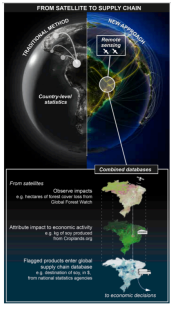
Future: Next up, climate change variability

- Next up = Climate change impacts and global scale



Future: Next up, climate change variability

Future Work: Remote Sensing Trade Models



Q & A