Network-based Pollutant Emission Allocation and Impact Assessment for Industrial Parks

Mai Su

Doctor candidate, School of Environment, Tsinghua University

China

sum23@mails.tsinghua.edu.cn

Instagram: maxine011112

CONTENT SLIDES

1. Introduction： why should allocate pollution emission in Industrial park

2. Method Framework ： how to build industrial network and simulate model

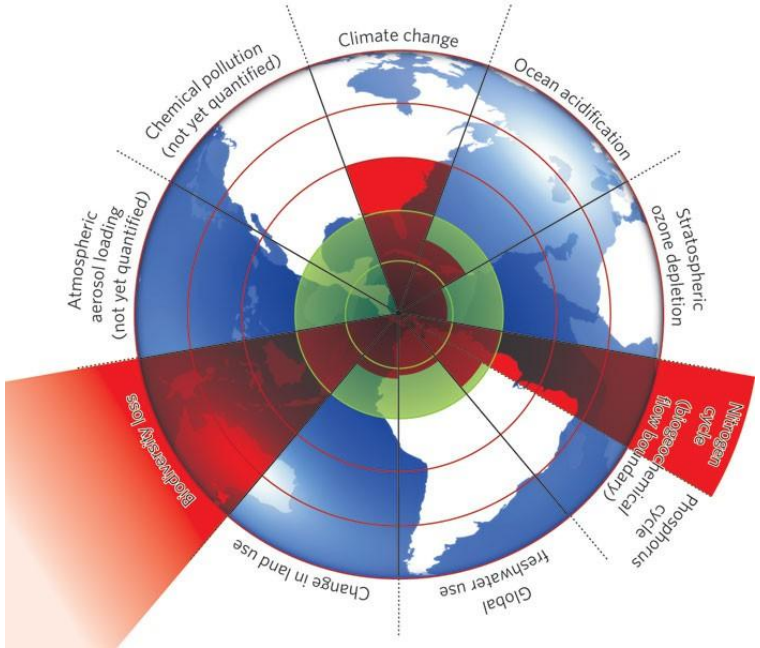
3. Method & Result ： The result of Industrial network and allocation

4. Future outlook ： Full chain of EIA and the application of AI

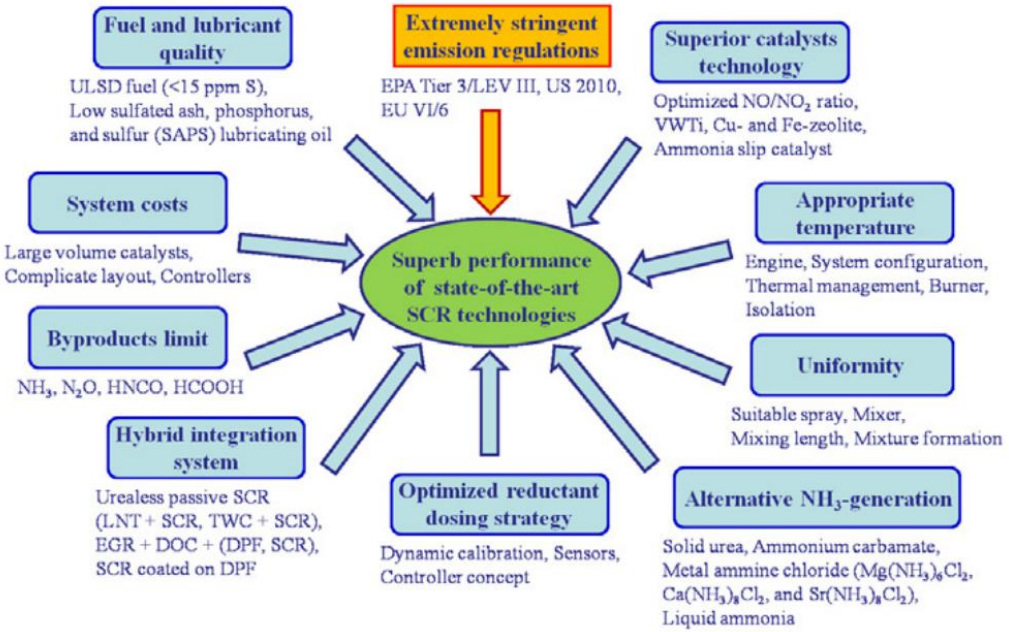
1. Introduction

Scale Mismatch in Pollution Management

- ***Environmental Limits:*** Human activities must operate within environmental capacity and emission limits.
- ***Meso Scale Miss:*** Studies tend to focus either on macro scale, such as planetary boundaries, or on micro scale, such as emission standards for specific technologies.



Beyond the boundary (Rockström, 2009)



Selective catalytic reduction of Nox from diesel engine exhaust (Guan, 2014)

1. Introduction

Scale Mismatch in Pollution Management

- ***Implementable & Targeted:*** *Regional environmental constraints can be translated to implementable and targeted pollution management measures.*

Macro-level:

Global environmental limits
Planetary Boundary

Allocation

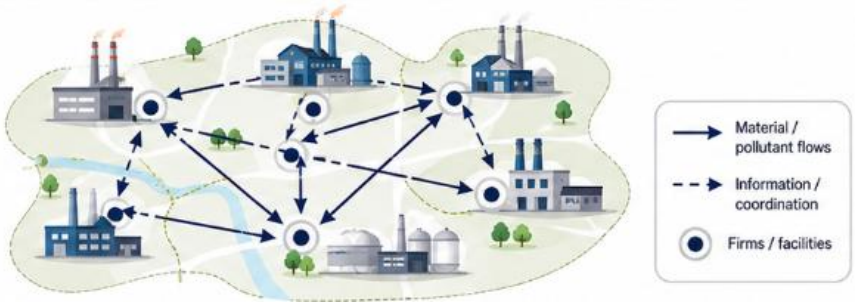
Feedback

Mismatch

Research focus

Meso-level

Regional environment management
Industrial Park interactions



Micro-level:

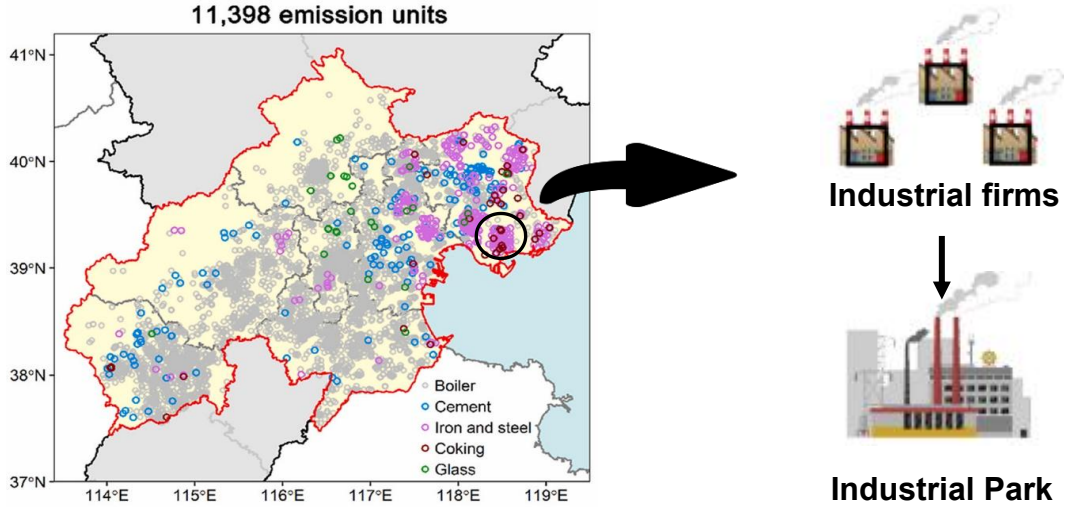
Best available technology
Firm/facility behaviors

Environmental Impact Assessment (EIA)

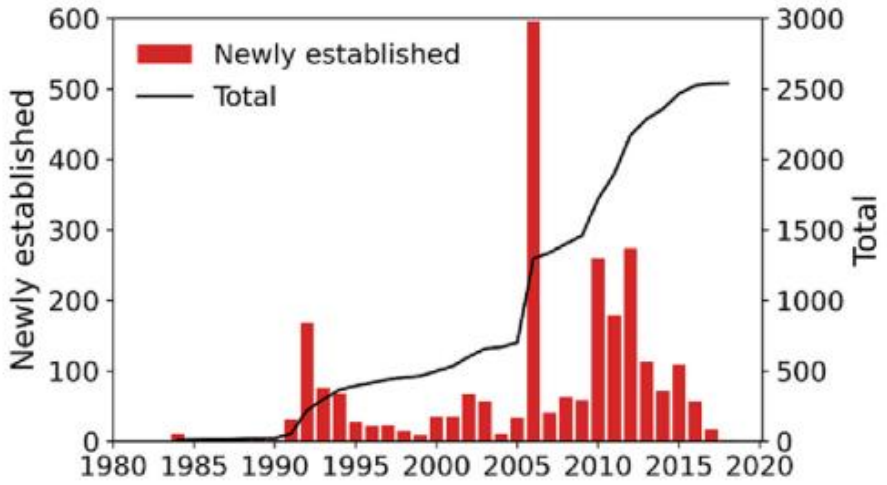
1. Introduction

The Importance of Pollutant Management in Industrial Parks

- ***Expand Tendency:*** Lots of industrial enterprise are quired to move or build in industrial park
- ***High emission & High output:*** Industrials Park is the biggest source of air pollutant emission in China and contribute more than 60% GDP
- ***Strong heterogeneity :*** Different parks have different industrial structures, different technologies, and different environmental pressures.



Air pollutant emission allocation of three methods in BTH region (Zhou, 2022)



The total number of industrial parks has increased year by year (Lu, 2023)

1. Introduction

Ecological and Environmental Zoning-based Regulation (EZR)

- ***EZR:*** A policy that divides land into different integrated ecological & environmental units (IEEUs) based on their nature, ecology and environmental conditions.
- ***Integrated Management:*** Each IEEU imposes specific requirements and constraints on industries operating within its boundaries

Protect-in-Prior IEEUs (IEEU-P)

Critical Regulatory IEEUs (IEEU-C)

Ordinary Restriction IEEUs (IEEU-O)

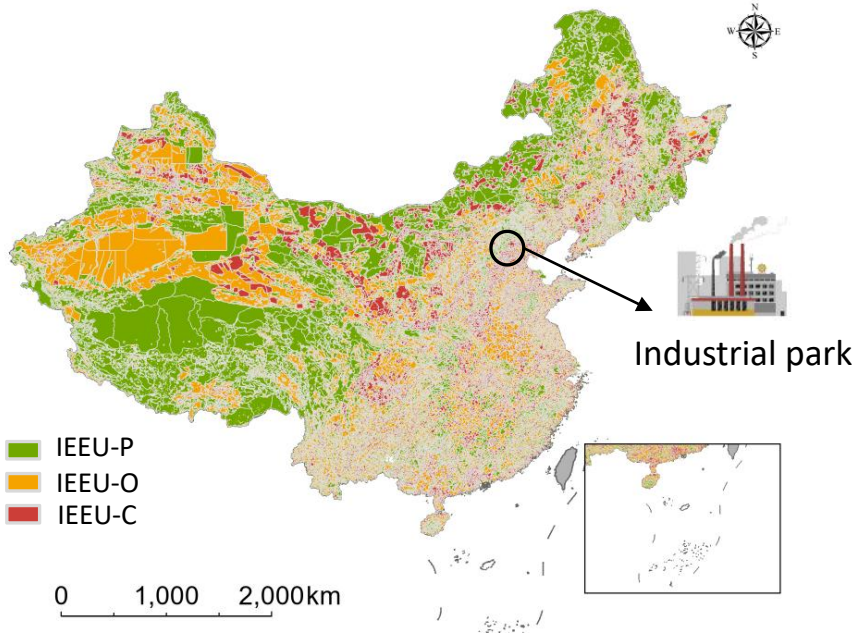
Constraints on industries

Spatial location constraints

Pollution emission quotas

Environmental technology requirements

List of Environmental Permits (LEPs)



The distribution of the type of IEEU

1. Introduction

Ecological and Environmental Zoning-based Regulation (EZR)

- ***"Who should reduce" :*** Pollutant management should address the allocation of emission among different units (e.g. industrial park, firms)
- ***Significant Impact :*** Park-level pollutant management directly affects both environmental compliance and industrial development

Critical Regulatory IEEUs (IEEU-C)

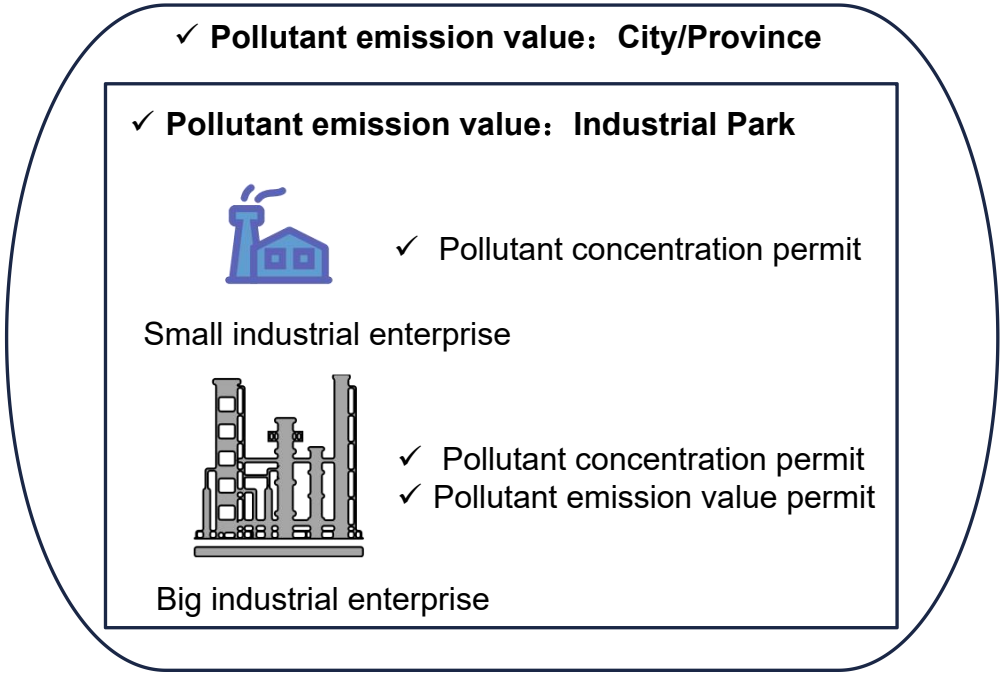
Pollution emission quotas

How to make the pollutant emission quotas ?

1. Introduction

The Total Emission Control in China

- ***Permit concentration and Amount control:*** Pollutant management increasingly requires control over both emission concentration and total emission amounts
- ***Allocation method:*** emission standard, environment capacity, pollution performance



① **Emission Standard** Based Allocation Method

Allowable Emissions
= Concentration standard × production

② **Environmental Capacity** Based Allocation Method

Allowable Emissions
= Environmental capacity × allocation share

③ **Pollution Performance** Based Allocation Method

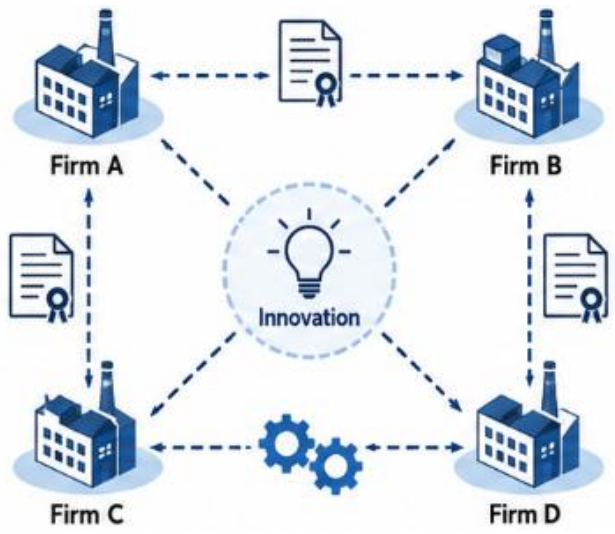
Allowable Emissions
= Total allowable× Economic output / Pollutant output

1. Introduction

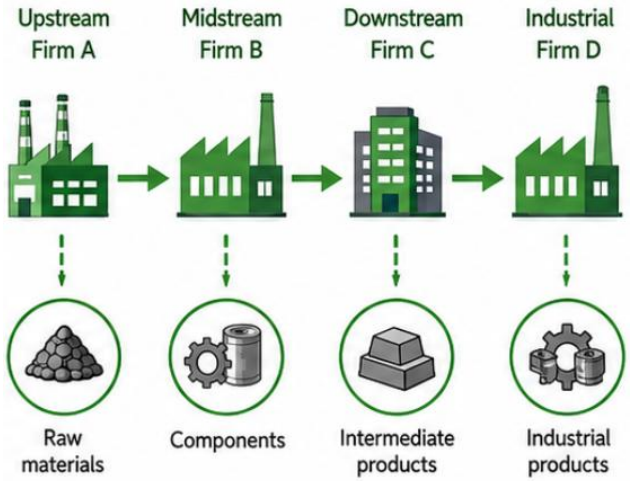
The overlook of interactions among Industrial Parks

- ***No firm operates in a vacuum:*** Firms in industrial park are embedded in supplier-customer, competition, and technology-cooperation relationships
- ***Industrial Network & Environmental Impact:*** the environmental performance propagate in industrial network

Technology Cooperation



Product Supply



Product Competition

2. Method Framework

Core logic — Build network relationships → Model enterprise behavior → Optimize regional allocation

Industrial Network

- **Network Construction**

Technological cooperation

Product competition

Product supply

- **Social Network Analysis**

Network structure

Centrality

Key firms

Enterprise Behavior Modeling

- **Enterprise Behavior Simulate**

Production

Technology upgrade

Relocation

- **Emission Simulation**

Firm-level emissions

Regional total emissions

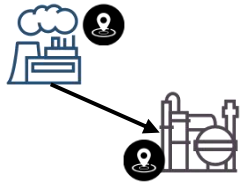
Allocation optimization

- **Regional Situation Analysis**

Regional amount value

vs.

Total pollution emissions



Key firms

Important supply chain

- **Allocation optimization**

Compare scenarios

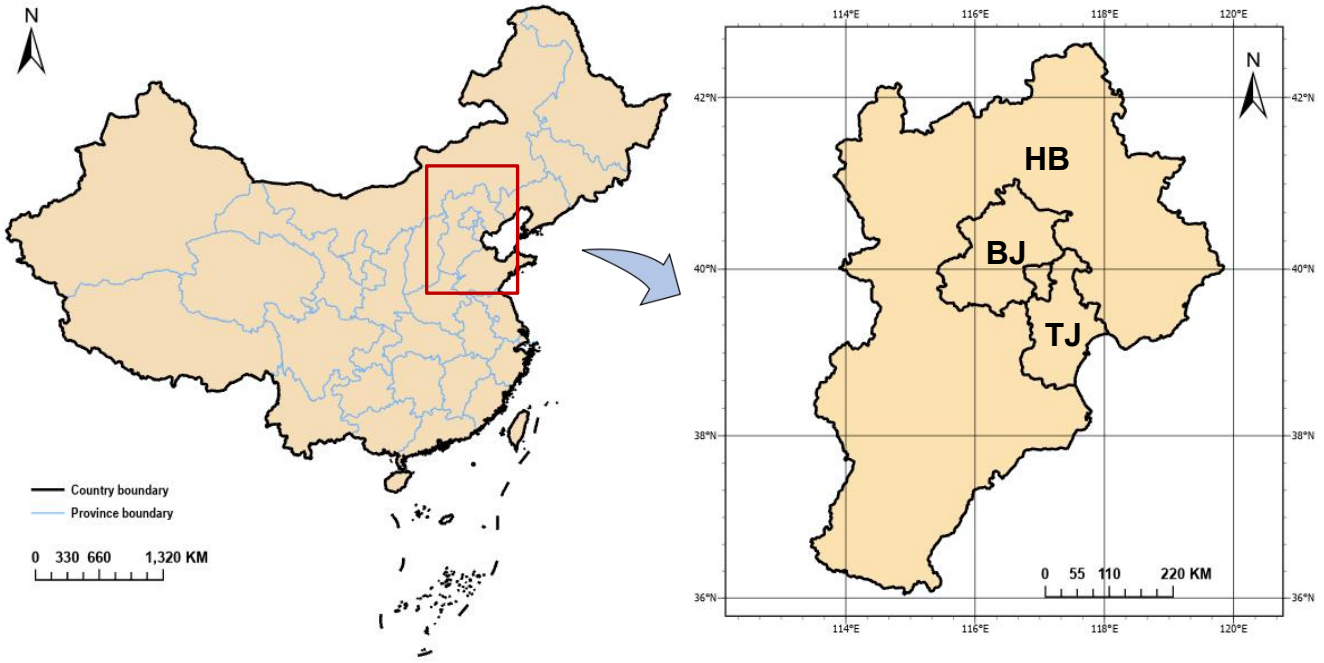
Emission Performance

Amount emission value

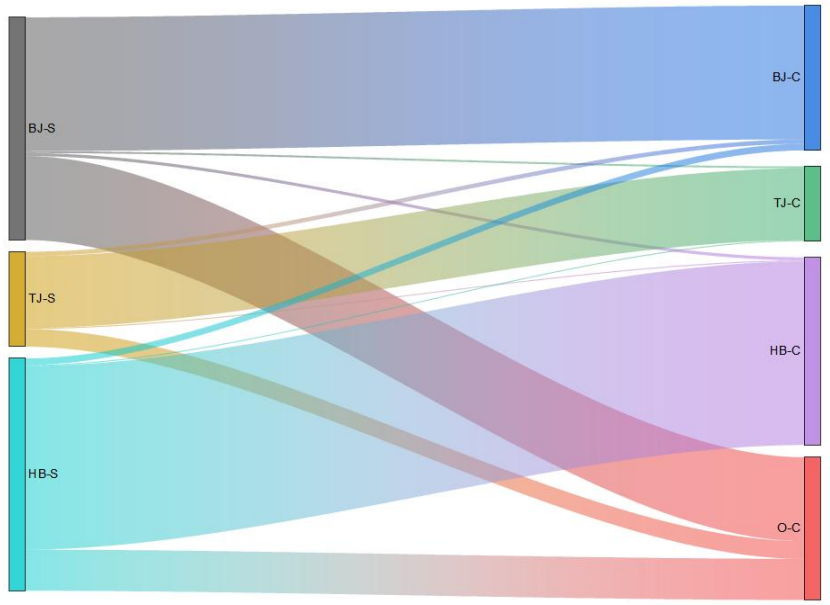
2. Method Framework

Case Area: Beijing-Tianjing-Hebei Region (BTH)

- ***Core Industrial Development:*** The BTH hosts a large number of industrial parks and manufacturing clusters, cross-regional trade and interregional industrial flows are representative.
- ***Environmental Quality Weak:*** The BTH contains many critical regulatory units, and its ecological and environmental quality still lags behind other major urban agglomerations.



Case Study：BTH region

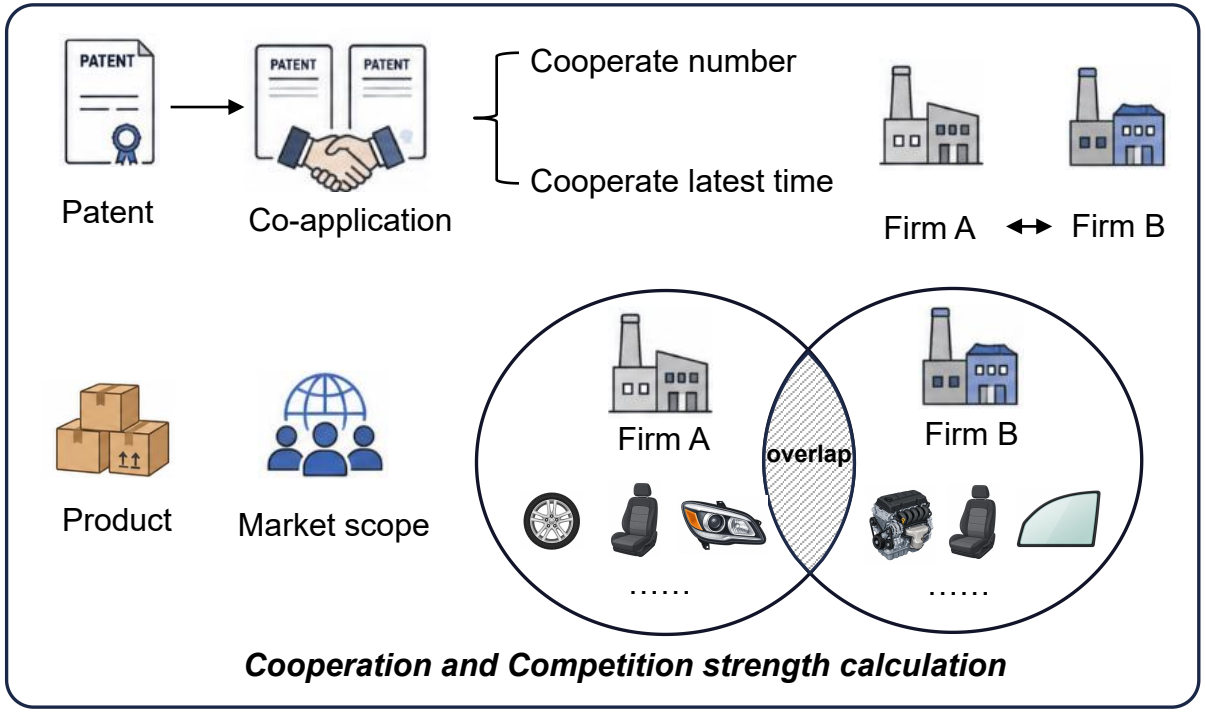


The intermediate input among BTH

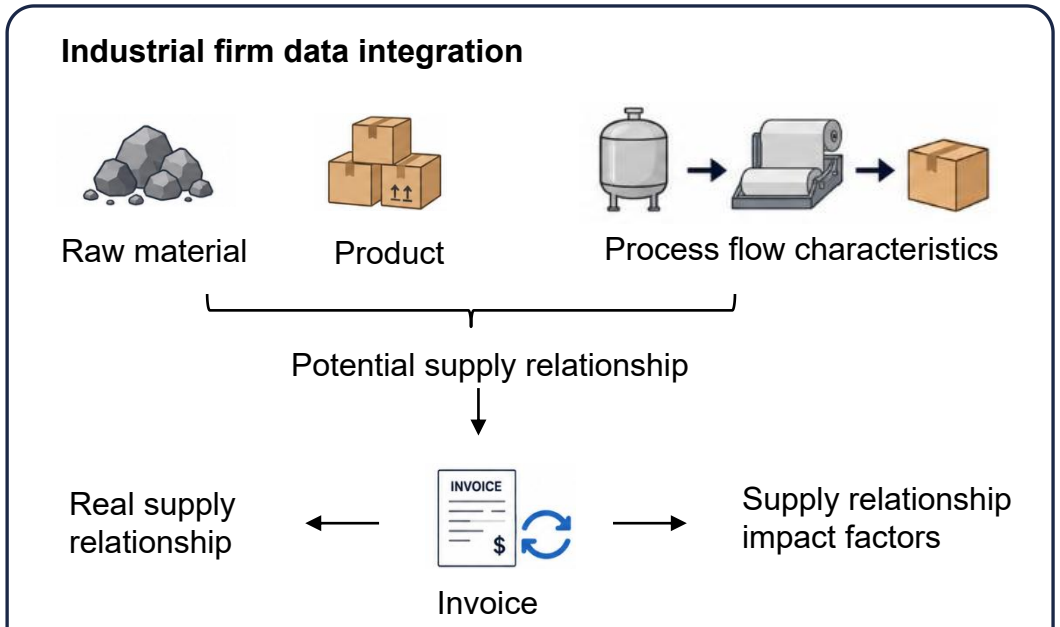
3. Method & Result

Industrial Network Construction

- ***Cooperation and Competition:*** Annual co-application patent records both the number of joint application and continuity, the degree of overlap in firms' product types and market scope.
- ***Supplier-Customer:*** integrate raw material types, product types, process-flow characteristics, and actual invoice transaction data.



Cooperation and Competition strength calculation

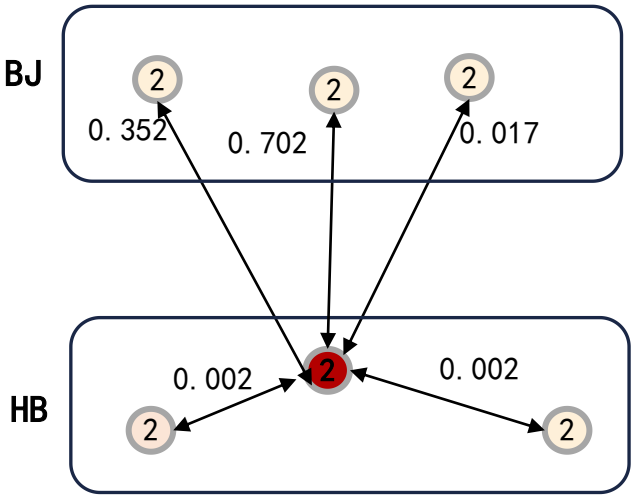


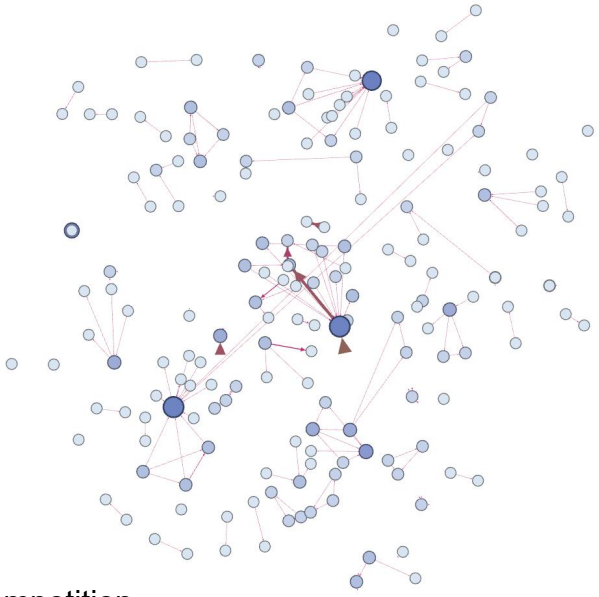
Supply relationship among industrial characteristic

3. Method & Result

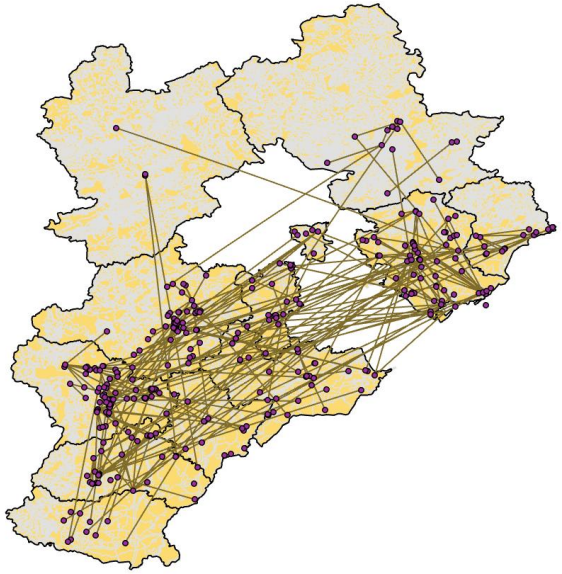
Industrial Network Characteristic

- ***Cooperation and Competition:*** the firms in HeBei tend to cooperate with head companies in Beijing, while intra-provincial cooperation is relatively rare. Meanwhile, industrial enterprises in HeBei face extremely fierce market competition.
- ***Supplier-Customer:*** the firm in HeBei tend to conduct procurement and supply activities within the province, with their major suppliers and customers predominantly located inside HeBei.





the network of cooperation and competition

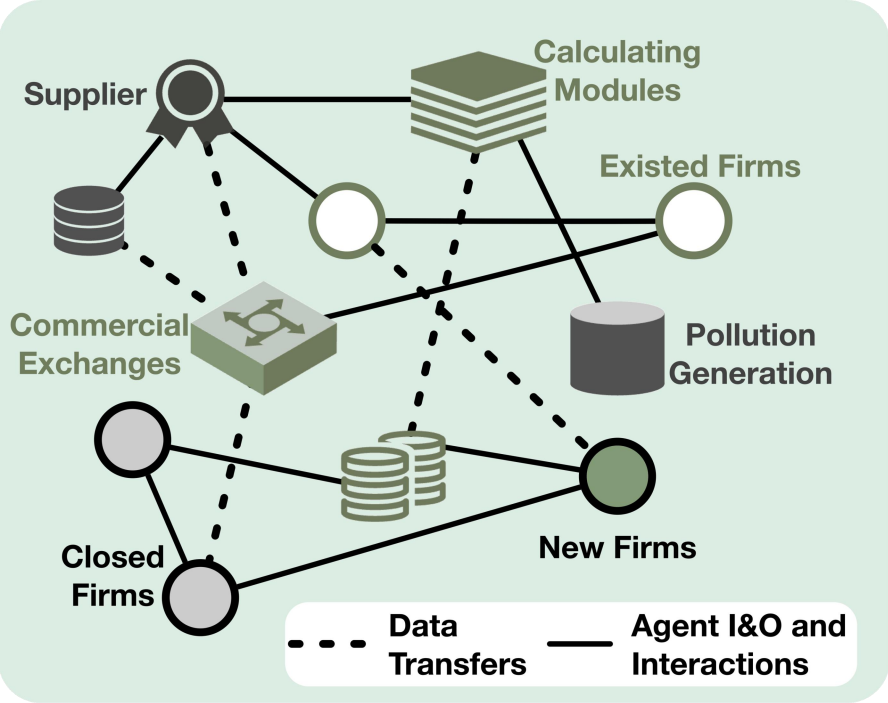


the supply chain in HB (just show less than 400 firms)

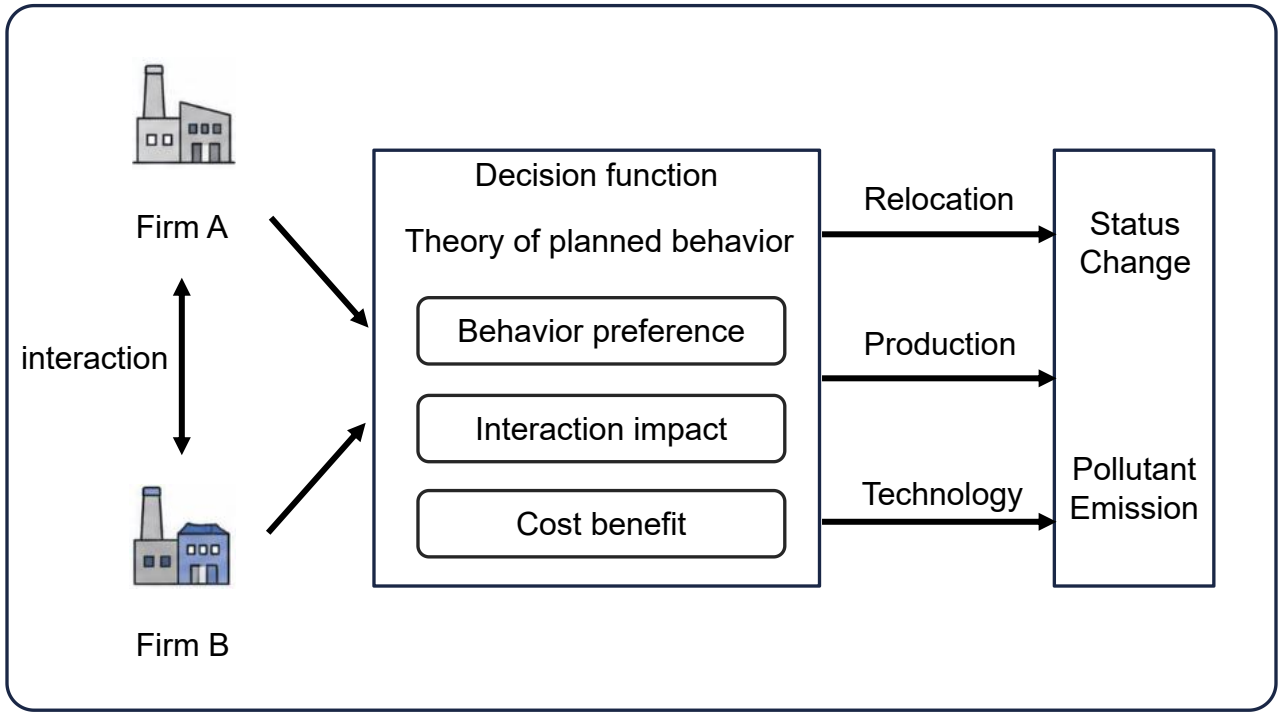
3. Method & Result

Modeling and Impact Assessment

- ***Agent Based Model:*** Identify the impact factors of firm behavior based on theory of planned behavior, simulate the firm decision when face industrial networks and policy measures.



A conceptual framework of Industrial ABM

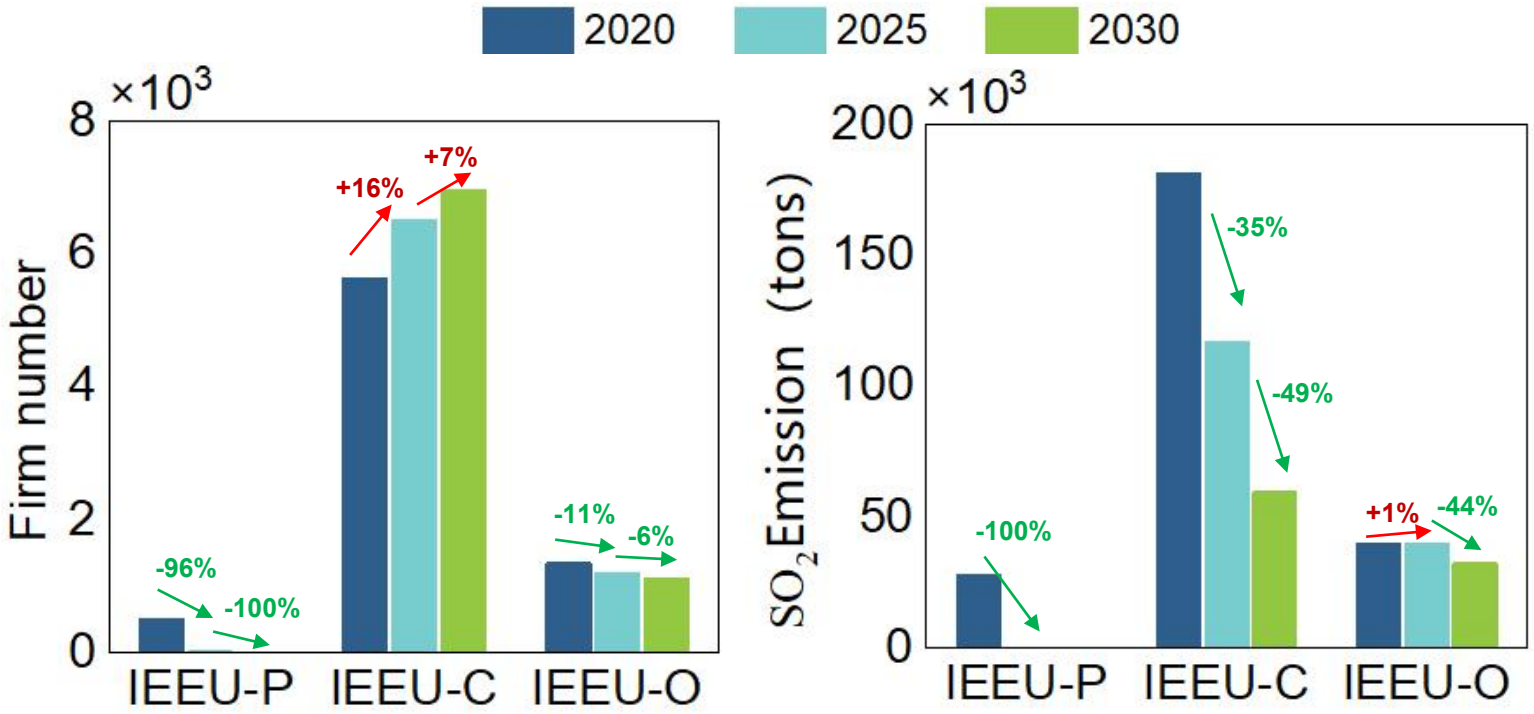


Firm module of ABM (github.com/WeizzyTHU/IMERGE-EZR)

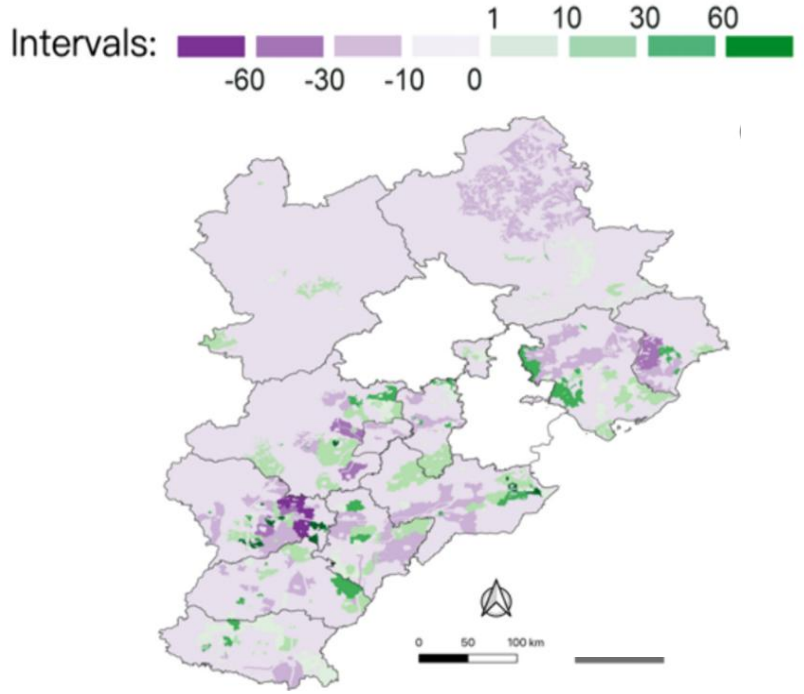
3. Method & Result

Modeling and Impact Assessment

- ***Spatiotemporal changes:*** Under EZR, firms become more concentrated in Critical Regulatory Units, and the regulation can reduce firms' pollutant emissions. Spatially, firms also tend to cluster around regional boundary areas.



Changes in firm number and emissions of three types units under EZR

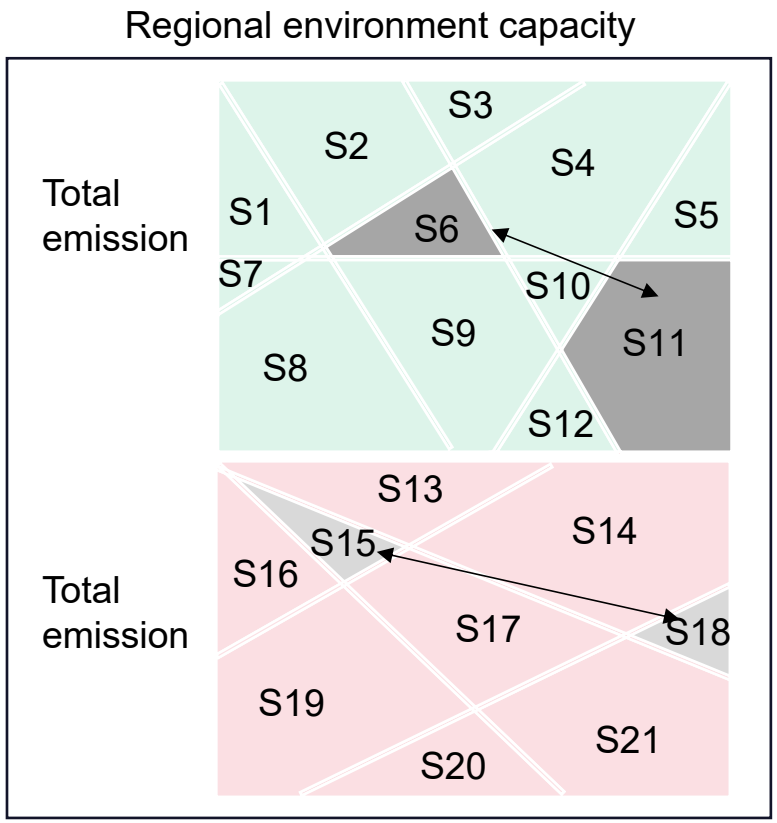


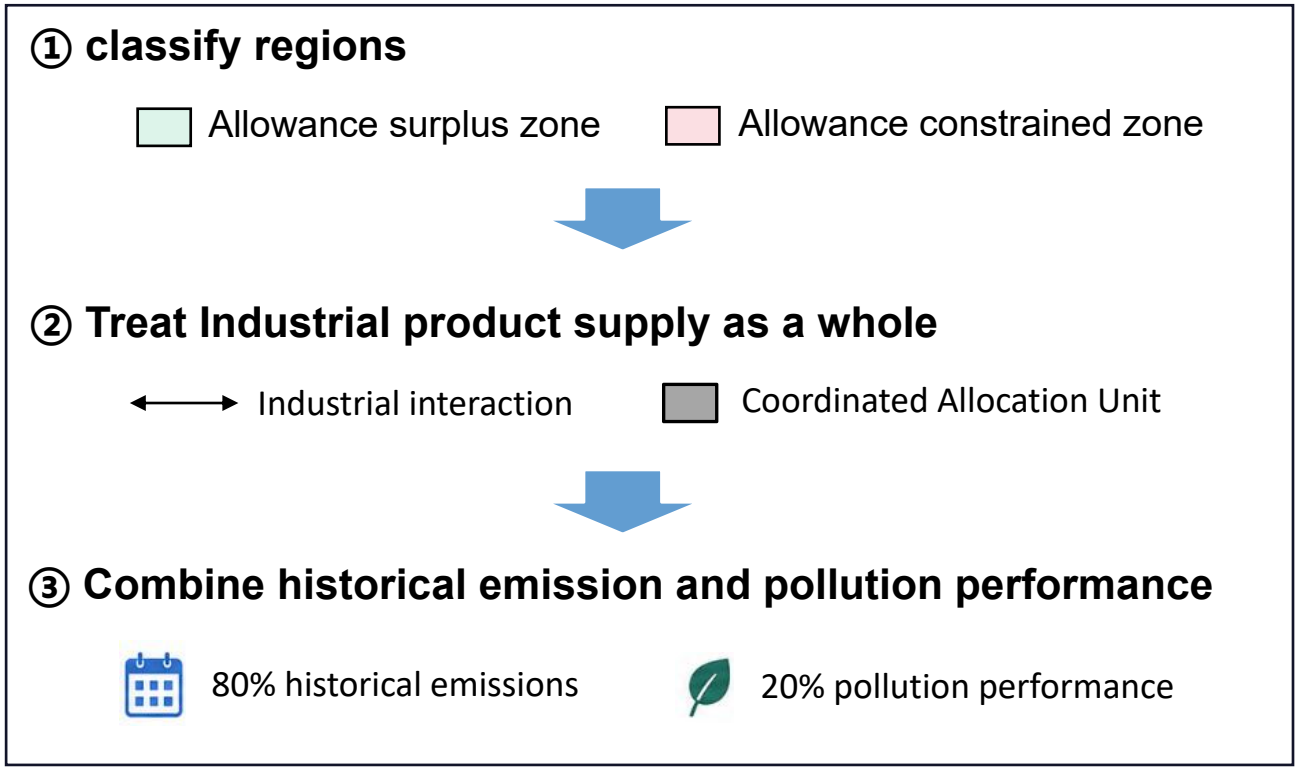
Changes of firm number in IEEUs from 2020 to 2025

3. Method & Result

Allocation Method

- ***Allocation Optimization:*** Integrate historical emissions, pollution performance, and industrial network to optimize the allocation of pollutant emission allowances.

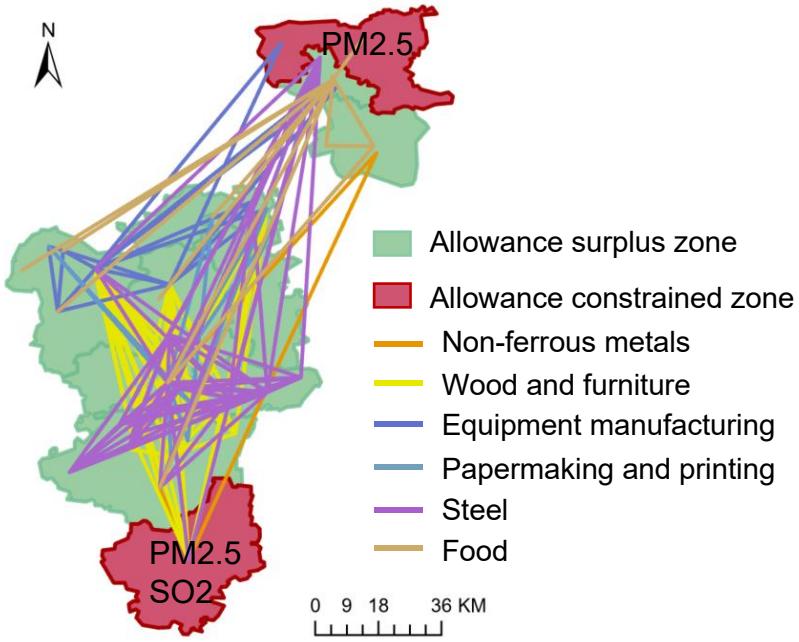




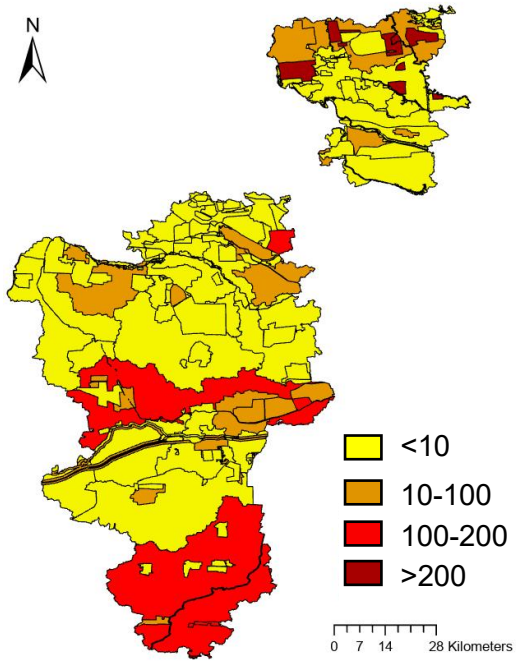
3. Method & Result

Allocation optimization

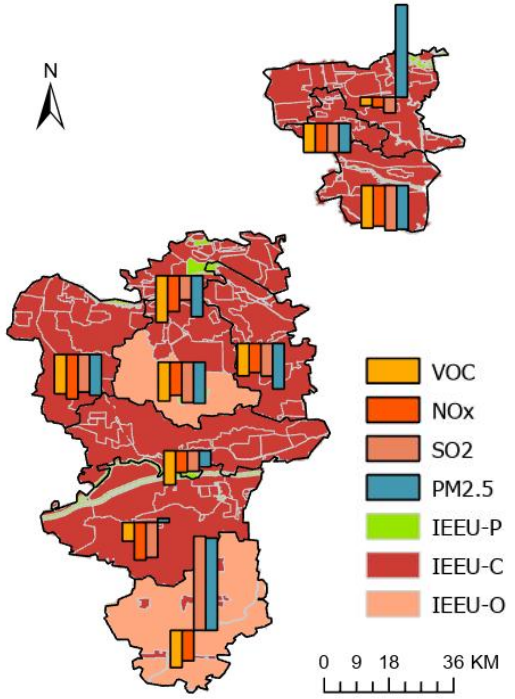
- ***Significant firms:*** the traditional pollutant emission industry, including steel smelting, furniture, and papermaking industry.
- ***Increase & Reduce:*** high industrial agglomeration and frequent supply-chain interactions are assigned moderately higher emission allowances.



the supply relationship in Langfang city (HB)



SO2 emission allowance of different zones



Different allocation optimization strategies

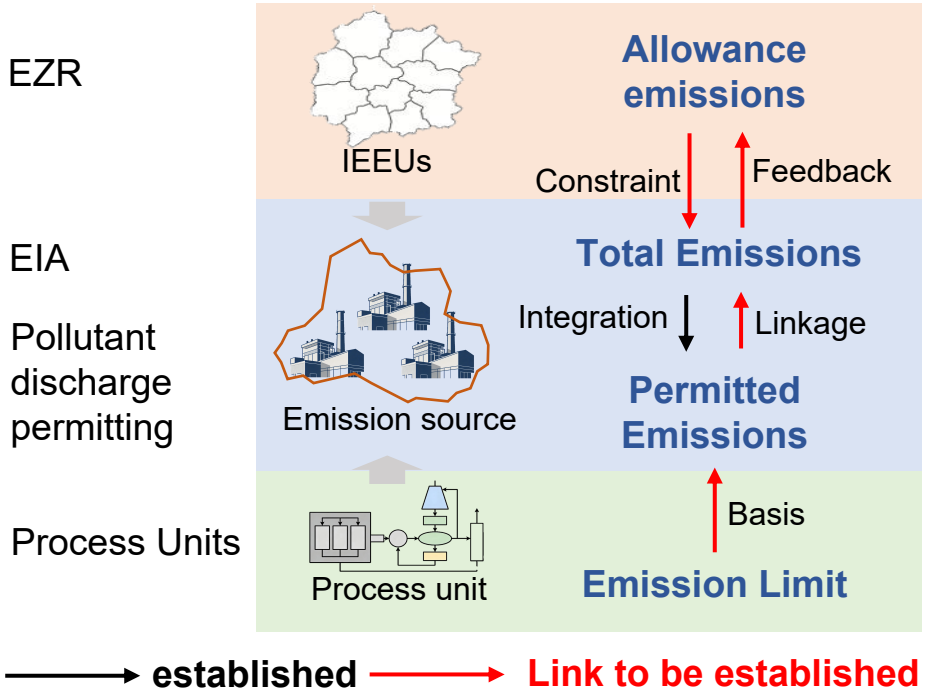
3. Conclusion and suggestion

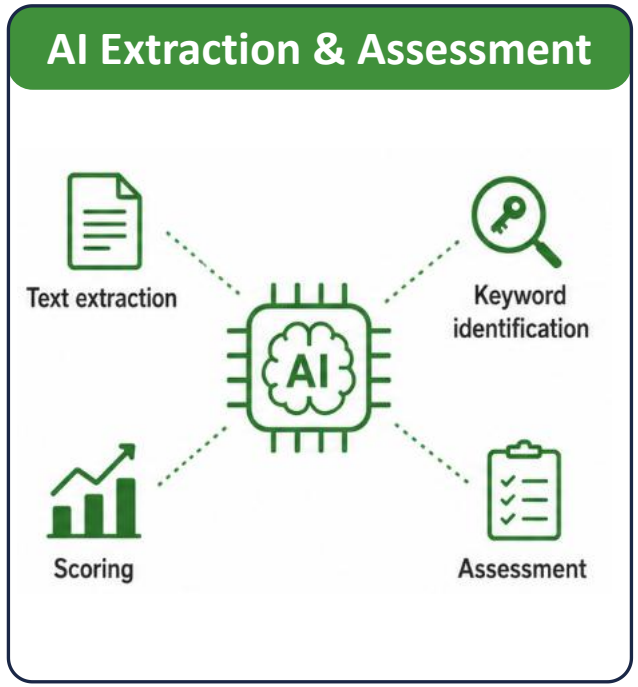
- ***Industrial Network Matter:*** Firms' emission outcomes are influenced by inter-firm relationships. Industrial networks should be incorporated into industrial-park pollutant management and firm-level environmental regulation.
- ***Spatially Differentiated EZR Effects:*** EZR affects firms through spatially differentiated constraints. Spatial regulation should consider both environmental constraints and industrial network roles, because policy impacts are not isolated.
- ***Network-Informed Allocation Optimization:*** Pollutant allocation should not treat firms or regions as isolated units. Historical emissions, pollution performance, and inter-firm relationships should be jointly considered.

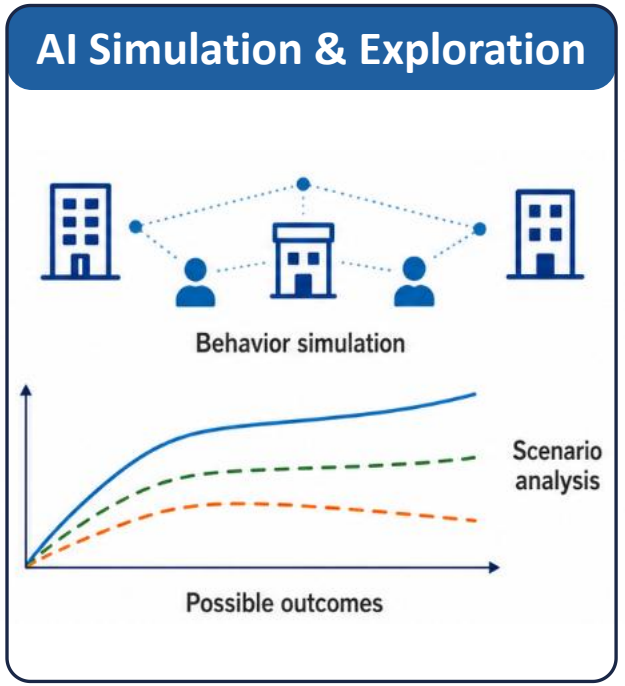
4. Future outlook

Environmental management and application of AI

- ***Full-chain reform:*** Link EIA, EZR, and pollutant discharge permitting to support integrated management of regions and key regulated objects.
- ***AI application:*** Support extraction, evaluation, and simulation in the full-chain reform linking EIA, EZR and pollutant discharge permitting.







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Mai Su

Doctor candidate, School of Environment, Tsinghua University

China

sum23@mails.tsinghua.edu.cn

Instagram: maxine011112

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