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RESEARCH ON THE RESILIENCE OF NODES IN ENERGY MINERAL RESOURCES SUPPLY CHAIN UNDER EMERGENCY RISK BASED ON MULTILAYER COMPLEX NETWORK

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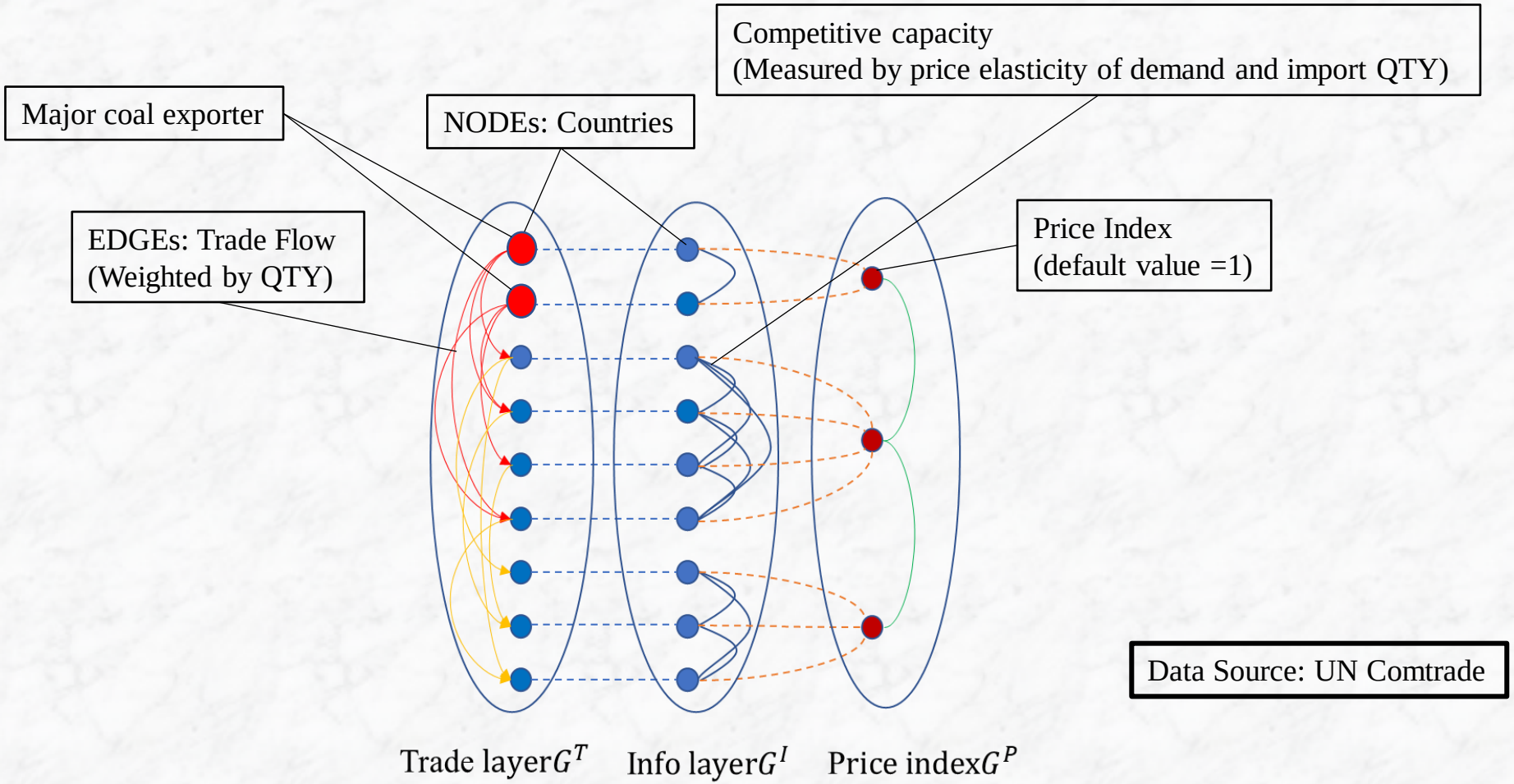
- Methods and Data
- Case Study
- Results
- Further Work

Overview

- **Coal electricity is of the largest proportion of electricity in many countries.**
- **With the severe changing international situation, the energy mineral resources is critical to the development of countries with seldom energy resource endowment, which makes the international trade of energy mineral resources of serious strategic importance.**
- **More and more factors begin to affect coal global supply chain network such as natural hazard, geographical politics and public health event.**
- **The resilience of system is a widely researched field of system science, which is defined as the capacity to recover from shocks (Risks). Enlighted by researches of engineering systems resilience, we proposed a new research framework to evaluate the resilience of nodes in the mineral resources trade network system.**

Methods and Data

- **Based on multilayer complex network theory, this paper models the supply chain network of energy mineral resources using a three-layer relational complex network---trade, information and price index layer.**



Methods and Data

The emergency risk is defined as a export reduction(ΔL) from a major mineral resource producing country (Risk Source).

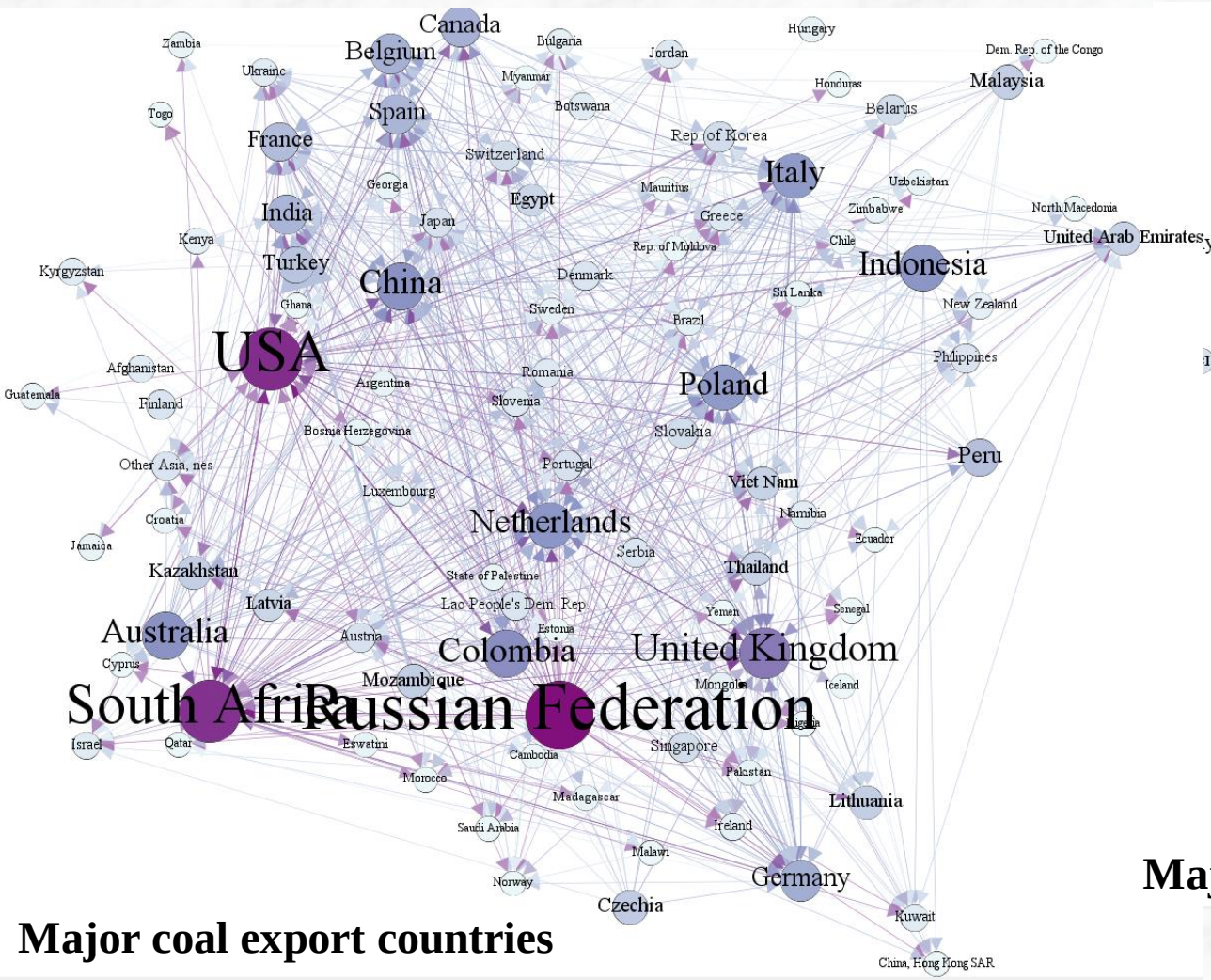
- **Period 1:** The nodes directly connected with RS are the first to be affected, the affected nodes suffer from import reductions and conducts the risk by reducing export to mitigate risk through the trade layer network. This process is similar to the PageRank algorithm of Google.
- **Period 2:** Due to the imbalance between supply and demand brought by risk, the price index of coal would change by Δh%, which attracts the other major coal producing countries to expand their production by β% in each period and the expanded production will be shared by nodes first being affected and also connected with these other major producer nodes. The share of each qualified nodes is calculated by the price elasticity of demand of each node and the import amount. In the mean while, the risk source would resume its production by α% in each period as well. The risk would be conducted again.
- **Period 3:** Repeat period 2, until the total production recovers to the original status, the risk is considered gone. The sum of all the import deficiency of each node is the total loss in this risk.
- **Period 4:** Enlighted by the concept of the price elasticity of demand, we calculate the resilience of each node by the following equation using the simulation results got from above :

$$ln(\Delta E_j) = lnA + \beta_2 ln(\Delta L_{Ni}) + \beta_3 ln(h)$$

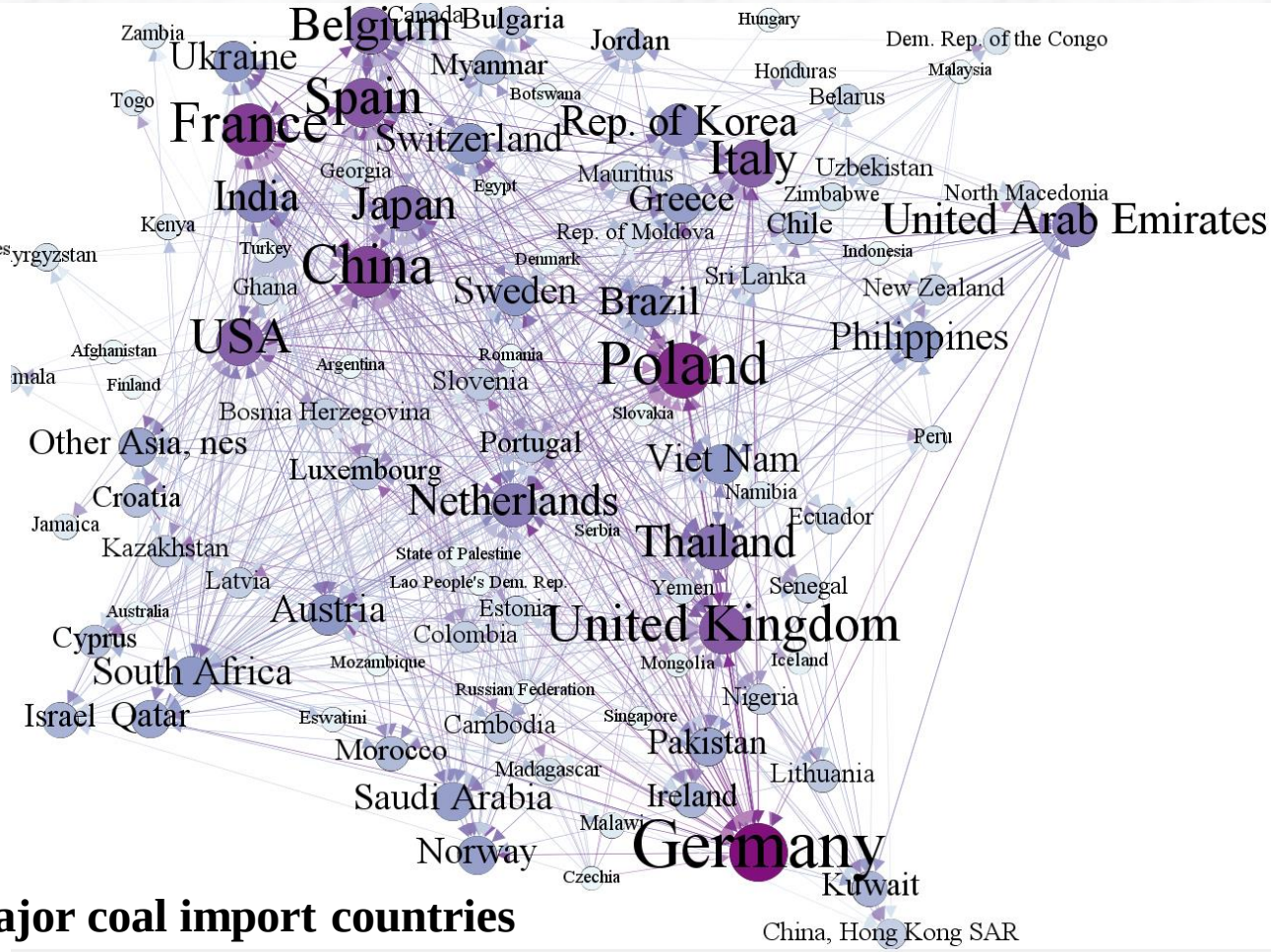
where ΔE_j is the total loss of node j, A is constant term, ΔL_{Ni} is the scale of risk(the amount of exportation reduce of risk source node), A is the constant term, h is the variation of price index, $-\beta 2$ is the resilience index we are looking for.

Case Study

- We chose coal to do the case study using the world trade data of 2019 (UN Comtrade), and calculate the price elasticity of demand of major coal import countries using the data of 2010-2019. We filtrated out 92 countries as the nodes of the network and over 770(2019) trade flows as the edges.



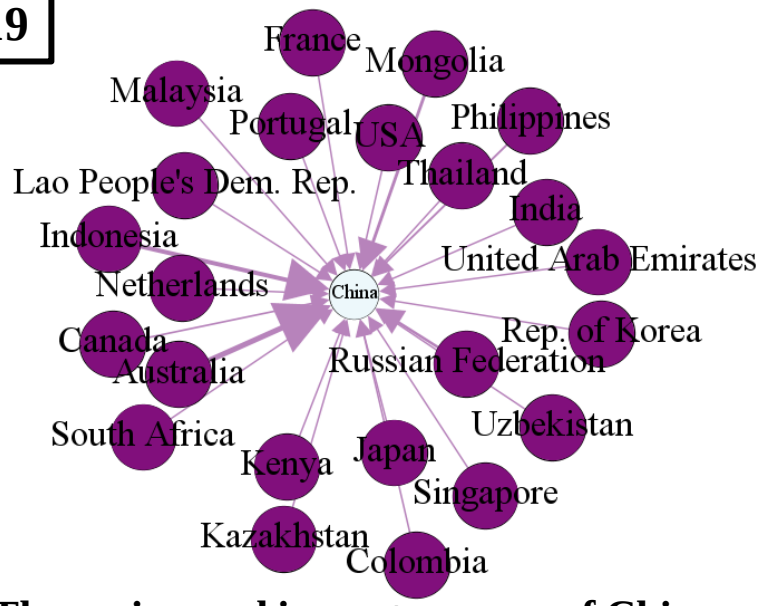
Major coal export countries



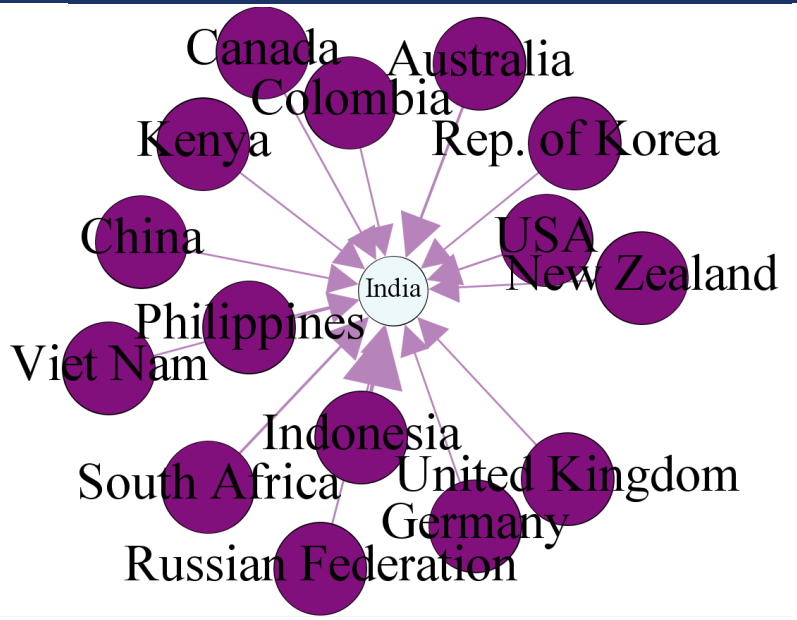
Major coal import countries

Case Study

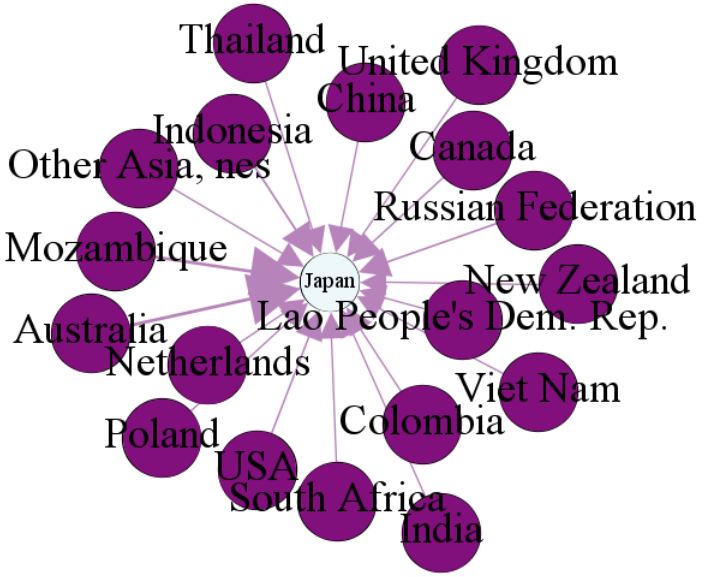
2019



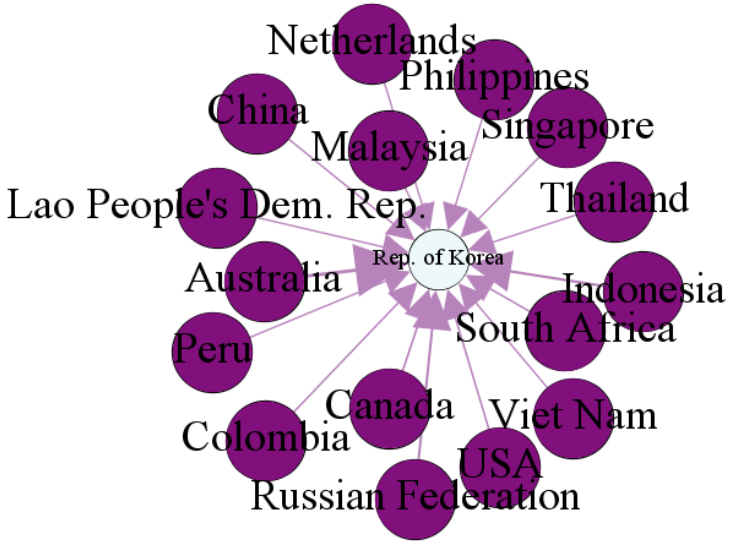
The major coal import sources of China



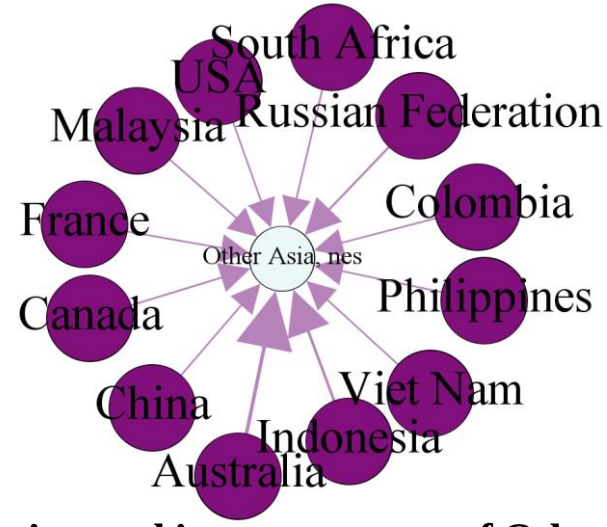
The major coal import sources of India



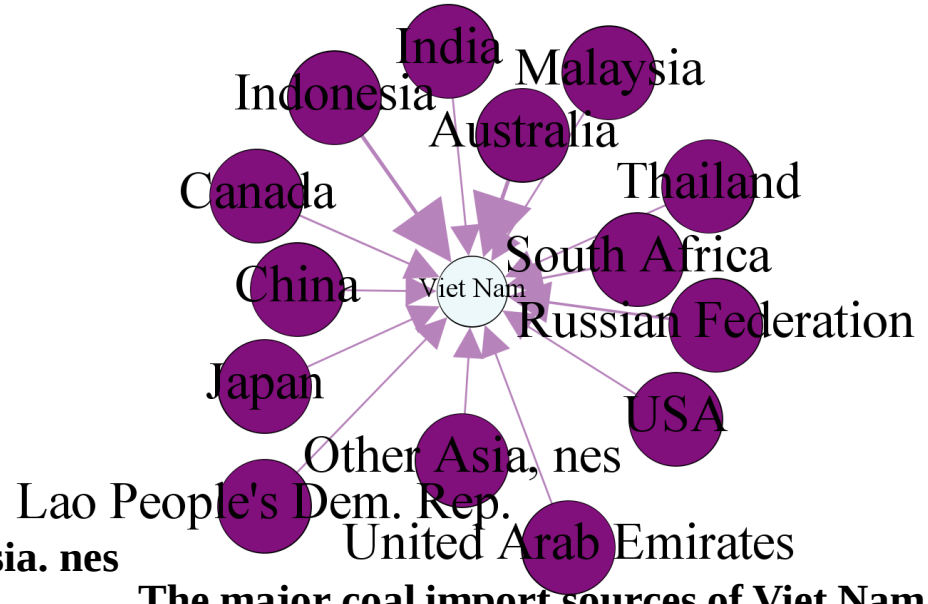
The major coal import sources of Japan



The major coal import sources of Rep. of Korea



The major coal import sources of Other Asia. nes

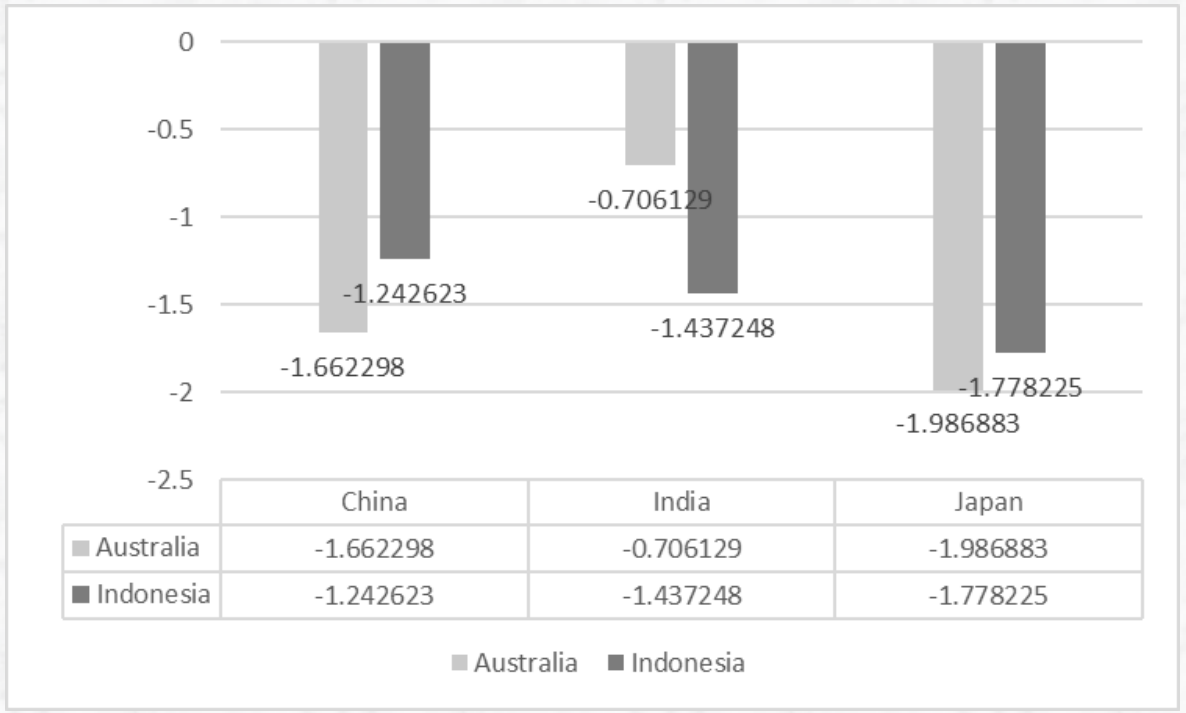


The major coal import sources of Viet Nam

Results

$$ln(\Delta E_j) = lnA + \beta_2 ln(\Delta L_{Ni}) + \beta_3 ln(h)$$

where ΔE_j is the total loss of node j, A is constant term, ΔL_{Ni} is the scale of risk(the amount of exportation reduce of risk source node), A is the constant term, h is the variation of price index, $-\beta 2$ is the resilience index we are looking for.



The values of the nodes' resilience calculated with our novel measurement is normally negative, meaning how much loss every 1% rise of the risk level of certain risk source will bring to target node.

- More import sources.
- More balanced import structure.
- Bargaining capacity.
- Higher utilization efficiency.

Further Work

- How the Community topology of the trade network affects the transmission of risk.
- The improvement of competitive capacity of nodes under risk.
- How to improve more benchmarks to the results.
- The relationship between price changes and production.
- …

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Thank you for your time!

Looking forward to your advice.

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