Applications of Complex Networks on Analysis of World Trade Network

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Abstract. We consider the wealth and the money flow of the world trade data. We analyze the world trade data from year 1948 to 2000 which include the total amounts of the import and export for every country per year. We apply the analyzing methods of the complex networks to the world trade network. We define the wealth as the gross domestic products (GDP) of each country. We defined the backbone network of the world trade network. We generate the backbone network keeping the link with the largest wealth flowing out each country by the import and deleting all remaining links. We observed that the wealth was transferred from the poorer countries to the wealthier countries. We found the asymmetry of the world trade flow by the disparity of the networks. From the backbone network of the world trade we can identify the regional economic connections and wealth flow among the countries.

1. Introduction

The economic and financial systems are complex systems which show many emerging properties. Many stylized facts reported on the time series of the stock market and foreign exchange \cite{1,2}. The complex networks were generated by the cross-correlations between the return time series of the stock indices and the foreign exchange rates \cite{1,2}. The minimal spanning trees of the correlation networks showed the scale-free behaviours. The world trade networks (WTN) are extracted from the world trade relationship among the countries \cite{3,4}. In WTN the nodes of the network corresponds to the countries and the size of the node is equal to the relative magnitude of the each country’s GDP. We connect the two countries if there are trading relationships such as the import or export. The width of the links corresponds to the relative size of the trading magnitude.

The world trade networks are almost fully connected networks because the country trade with other countries over the world. We consider two types of the network: the backbone networks and the minimal spanning trees of the world trade network. These sub-networks extracted from the original world trade networks. We can understand the main stream of the world trade from these networks. In the backbone networks of WTN shows the flowing dynamics of the money and inter-dependence among the countries by the world trade. We indicate the change of the trading structures when we plot the backbone networks of WTN each year. We also observe the economic zone built by the main stream of the world trade.

We consider the wealth asymmetry of the world trade in the section 2. We extract the backbone network of the WTN in section 3. We generate the minimal spanning trees of the WTN in the section 4. We gave the conclusion remarks in the section 5.

2. Wealth Asymmetry of World Trade Network

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We consider the global domestic products (GDP) and data of the world trade from year 1950 to year 2000[5]. We define the wealth of a country as the GDP of the country. In the world trade network the node is the country and the size of the node is equal to the relative magnitude of the wealth. The wealth of a country, $i$, is defined by the its GDP, $G_i(t)$, where $t$ is a year. The money flows from country $j$ to country $i$ by the export of the country $i$. We denote that the amount of the money, $f_{ij}(t)$, corresponds to the money flowing into the country $i$ from country $j$ by the export of the country $i$ to the country $j$ at the year $t$. We observed the asymmetric wealth transfers measured by the wealth fractions belonging to the top 20% country and the bottom 20% country. Figure 1 shows the wealth fraction for the rich country and poor country over the year. In the observed period the wealth of the top 20% rich country increase monotonically, but the wealth of the bottom 20% poor country decrease. Although the total wealth of the world are increasing monotonically over the year, the portions of the wealth owned by the rich country increase more quickly.

![Figure 1. Wealth fractions over the year belong to the top 20% rich country and bottom 20% poor country. The wealth is transferring from the poorer country to the richer country in the observed period.](image)

3. Backbone Network
We generate the backbone networks of the world trade network. We keep the link of the largest money transfer of each country by the import and delete all other connections. In Figure 2 we present a backbone network of the WTN in year 2000. In the network the size of the node corresponds to the relative magnitude of the GDPs and the width corresponds to the relative magnitude of the money flowing out from the country. From the backbone network we can identify the main stream of the money flow by the import. We can also observe the economic zone by the money flows. These economic zones are very similar to the regional economic zone such as EU economic zone, USA economic zone, Asia economic zone etc.

In the backbone network of year 2000 we observe that USA, Japan (JPN) and German Federal Republic (GFR) are the sink country of the wealth. These countries absorb the wealth by the world trade. An interesting pattern exists in east-Asian economic zone. The money circulation occurs at the countries: Japan-United Arab Emirate-China-Korea-Japan cycle. Japan is one of the largest money absorbing country all over the world.
4. Minimal Spanning Tree

Minimal Spanning Tree (MST) generated from the world trade network. We use the Kruskal algorithm to extract the MST in the WTN. In the MST we keep the largest trading links up to (N-1) links. Figure 3 presents the MST in year 2000. This MST is similar to the backbone network of Figure 2. However, there is big difference between two networks. In the backbone network the circular loop can exist, but in the MST the network is just a tree and there is no loop structure. In the MST we also observe the economic zone by the world trade. In the MST we can identify the most influential countries: USA, China, Japan, German Federal Republic, etc. German Federal Republic is the most important trading country in the European countries.
Figure 3. Minimal spanning tree (MST) generated by the import relationship in year 2000. The size of node corresponds to the relative magnitude of the GDPs. The width of the link corresponds to the relative magnitude of the money flowing out.

5. Conclusions
We observed the asymmetry of the world trade network. We generated the backbone network and the minimal spanning trees of the world trade network. We can identify the wealth flow and the formation of sub-economic zone in these networks.

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References
[1] Mantegna R N and Stanley H E An Introduction to Econophysics: Correlations and Complexity in Finance (Cambridge University Press, New York, 2000) p 20
[2] Voit J The Statistical Mechanics of Financial Markets (Springer, Berlin, 2001) P 59.
[3] Fagiolo G, Reyes J and Schiavo S 2009 Phys. Rev. E 79 036115
[4] Garlaschelli D, Di Matteo T, Aste T, Caldarelli G and Loffredo M. I 2007 Eur. Phys. J. B 57 159
[5] Gleditsch K S 2002 J. Conflict Resolut. 46 712