Studies on Graph Optimization and Network Indicators in Economic Structure Analysis

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（経済構造分析におけるグラフ最適化とネットワーク指標に関する研究）

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論　文　内　容　の　要　旨

In the field of economic structure analysis, a nature of economy as a network has been focused on. A network is a discrete structure that consists of (weighted) vertices and (weighted) edges that connect vertices. In the context of economic analysis, vertices represent industries, sectors, companies or individuals, and edges represent transactions between them. In weighted cases, the weight of a vertex or an edge represents its magnitude. For example, if a vertex corresponds to an industry, its production volume is represented as the vertex weight, and if an edge corresponds to a transaction between two industries, the amount of money or materials transferred between them is represented as the edge weight.

In general, a graphical/network representation gives an intuitive observation about the local/global structure of connections. Thus a typical usage of economic network model is to identify a group of industries/transactions that play a key role in economy. This type of analyses are also useful to capture flow of certain things on a network. In fact, in the field of environmental economics, economic network analysis is used to discover industries and transactions with high environmental burden of pollutants caused by economic activities.

The network analysis methods are roughly categorized into two approaches. One is graph optimization approach, and the other is network indicator approach. The graph optimization approach works as follows: We first model the task of analysis as a graph optimization problem. We then apply an algorithm to solve the problem, and obtain a solution. The solution implies analytical results about the network to be considered.

The network indicators reflect the characteristics of the network. Typically, these indicators are defined for vertices and/or edges, which represent their importance. The network indicator approach quantitatively argues the features of the network via the indicators.

The graph optimization approach and the network indicator approach have been applied to economic network analysis and they are promising in the field of economic structure analysis. In this thesis, we reorganize and develop the graph optimization approach and the network indicator approach from the viewpoint of economic structure analysis. This thesis consists of six chapters.

In Chapter 1, we provide the research background, motivation and contribution of this thesis. We also give the thesis overview.

Chapter 2 is the preliminary part. We give common definitions and notations used in this thesis.

In Chapters 3 and 4, we study the graph optimization approach in economic structure analysis. We first model the task to extract important structures from economic networks as graph optimization problems. We then design high-performance algorithms to solve the problems. We also investigate the computational complexity of the problems.

In Chapter 5, we focus on the network indicator approach. We propose a new economic network analysis method by using two economic network indicators: vertex betweenness centrality proposed by Liang et al. in 2016 and edge betweenness centrality proposed in this thesis. This method identifies environmentally critical transmission sectors, transactions and paths in global supply chain networks. As the empirical analysis, we use the world input-output database (WIOD) covering 35 industrial sectors and 41 countries and regions in 2008. We compute the vertex and edge betweenness centralities for WIOD. Moreover, we visualize CO_2 networks in the global supply chains based on the vertex and edge betweenness centralities. Finally, we discuss effective environmental policies from the results.

In Chapter 6, we summarize our study in this thesis and mention our contribution to this field.