Classification of Trading Networks with Nonlinear Integer Models

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Abstract: Trading networks can be modeled as directed graphs: The vertices correspond to companies or countries, the arcs indicate the flow of trade goods within a given period of time.

The underlying trading markets can be organized in different ways. Some resemble production chains, where goods are iteratively sold from one group of companies to the next one (*hierarchical* market structure). Others have a group of companies in the center of the market, which sell their goods to several peripheral company groups (*center-peripheral* market structure). To classify a given market in this manner is hence interesting from both a scientific and a strategic viewpoint.

The market classification can be modeled as a combinatorial optimization problem. We express it as a nonlinear integer program, which is actually a generalization of well-known problems such as the Quadratic Assignment, Linear Ordering, and the Traveling Salesman Problem. An exact solver is presented which uses new linearization techniques and exploits the relations to the problem's well-known special cases. It is able to classify networks up to 10,000 times faster than comparable approaches from the literature.

The solver is applied to real-world trading network data. We present results for the recent trading between German photo agencies as well as for international trading data provided by the United Nations.

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