464d Extended Input-Output Analysis for System Sustainability Assessment and Prediction

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Industrial sustainability is a vital issue in pursuing industrial long-term development. This is closely related to the material and energy efficiency in an industrial zone, region, or beyond. While an assessment of material and energy efficiency for a known system is relatively easy, a prediction of future system behavior is a challenging task, especially when the prediction horizon is significant, e.g., years and decades. This is particularly true when the assessment is about the system impact on future economics, environment, and society, where the available information is almost always uncertain, incomplete, and imprecise. Although a large number of case studies on this subject have been conducted in industries, a development of general, systematic methodologies of sustainability assessement is clearly a need.

This paper introduces a general mathematical framework of a sustainability assessement methodology, which is developed through extending an existing Econogical Input-Output Analysis (EIOA) method. The methodology is capable of manipulating both linguistic and numerical information. The linguistic informaiton is basically that related to environmental regulations, economic development conditions, technological advances, and social needs. This class of information is represented by fuzzy heuristic rules which is suitable for handling subjective uncertainties. The numerical informaiton is about system inflows, outflows, and throughflows that characterize each individual as well as the entire system behavior. Uncertainties associated with the numerical information will be processed statiscially. Procedurewise, the methodology consists of four major functional components that are activated iteractively: (i) an information gathering procedure, which is for data collection and classification, (ii) a quantitative analysis procedure, which focuses on system-balance-based flow analysis, (iii) a sustainability quantification procedure, which is largely based on the AIChE Sustainability Metrics, and (iv) a system sustainability enhancement procedure, which is for identifying the bottleneck of sustainability and providing possible solutions. The methodology can be used to conduct a comprehensive analysis on sustainability of an industrial system of any complexity, in principle. To illustrate the efficacy of the methodology, a case study on an automotive-manufacturing-centered chemical-material-manufacturing-surrounded complex system is analyzed and recommendations for its sustainable development are provided.