Evolution of Industrial Carbon Flow Network in Japan 1975 – 2000: A Laplacian Graph Analysis

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Abstract

Current carbon-based energy systems have evolved to form a fabric of complex interactions involving socio-economic, political and technological drivers. Despite the complexity and incalculable nature of the individual components of these micro-level interactions over time, the structure of the industrial carbon network exhibits a variety of recognizable and persistent evolutionary patterns. The objective of the current study was to identify the emergent patterns associated with the evolution of the industrial carbon network in Japan for the period between 1975 and 2000, and to describe these within a theoretical and empirical context. The theoretical analysis reconciles Minimal Flow Analysis (Schnable, 1995; Weber & Schnable, 1998) with Laplacian Graph Analysis (e.g., Fiedler, 1973, 1975; Merris, 1994, 1997, 1998) to facilitate a unique framework for analysis that can then be applied to elucidate the evolution of the industrial carbon network in Japan between 1975 and 2000. The Laplacian graph for each year is estimated by setting a threshold value for cumulative carbon emissions estimated from IO tables (395 sectors) for 1975, 1980, 1975, 1980, 1985, 1990, 1995, and 2000. The comparative network approach enables us to not only visualize the changes in core carbon network clusters (i.e. environmentally-influenced industrial clusters) and key sectors, but also to examine changes in the carbon emissions associated with the key clusters and their complementary graphs. The preliminary findings illustrate the nature of structural change toward the development of a service-oriented society and the contribution of improved energy efficiency over a 25-year period in shaping the evolution of the industrial carbon network in Japan.

Keywords: industrial carbon network, Minimal Flow Analysis, Laplacian graph theory, emergent pattern, evolution.