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Abstract: An Application of Markov Chains to Global Supply Chains

Markovian models have a considerable history in ecology where they have been applied to nutrient and energy flows in ecosystems (Barber, 1978). The relationship between input-output models and Markov chains has been exploited in ecosystem analysis (Patten and Finn, 1979), and the potential application of these ecosystem analysis techniques to industrial systems was recognized by Bailey *et al*. (2004a,b). In a recent paper Duchin and Levine for the first time developed and applied a Markov chain model to study supply chains within economic networks at the global scale. Their Markovian model relies upon essentially the same database as an economic input-output model; consequently, the two methods complement and supplement one another. However, this new formulation offers distinct advantages and capabilities not found in input-output techniques or any other path-based analytic techniques, namely a complete description of each stage in the myriad of network paths along which the various factors of production in different countries are transformed into goods and services purchased by final consumers in all countries. Furthermore, the paths can be described with flows measured in physical units or in price units.

In two recent papers Yamada *et al*.(2006a,b) develop an application of Markov chains to calculate the average number of times an individual material is used in a hypothetical economy. In this paper we build on that innovation and combine it with an input-output representation of production and consumption at a world-wide level. In the combined system, we are able to augment our prior framework to identify and quantify potential paths for material recycling. Analysis of economic systems at this scale has generally been reserved for economic input-output models, but only in combination with Markov chains are they able to provide system measures of the extent of recycling.

Keywords: Markov Chains, Input-Output Models, Recycling, Network Theory, Ecosystem Analysis