T. Di Stefano, G. Marin, M. Riccaboni: Global Virtual Water Trade: Integrating Structural Decomposition Analysis with Network Theory. A case study from 1995 to 2009.

Motivation and aims

The observed increase in the intensity of global trade patterns in recent decades, together with the increasing disintegration of the value chains across countries, calls for the elaboration of critical information about the nature of these trade flows. Taking into account both the direct and the indirect effects of global production and trade is the first step in order to assess the sustainability of resource exploitation. This paper applies a Multi-Regional Input-Output (MRIO) model to quantify the interdependencies of different sectors, within the global economy, and to determine the whole water usage of each country to satisfy its domestic final demand. This procedure allows the computation of Virtual Water Trade, that is the volume of water embodied in the goods shipped to other countries. In addition to baseline estimates of Virtual Water Trade based on the established static Input-Output modelling, we provide three additional and novel pieces of evidence on the Virtual Water Trade network. First, we investigate the dynamic evolution, from 1995 to 2009, of the structure of the international trade to disentangle the effect of technological change from the effect of a variation in import and export volumes. Second, we assess the convergence in the technology of production among different countries in terms of both water use intensity and structure of intermediate inputs. Finally, we introduce other indeces from Network Theory (e.g. pagerank, assortativity and clustering) to be compared with traditional indicators of resource use multipliers (e.g. backward and forward linkages).

Results are based on the latest version (November 2013) of the World Input Output Database - WIOD (http://www.wiod.org). The WIOD database covers 40 countries (EU27, US, Japan, China, India, Brazil among others) which cover more than of 85% of the global GDP. The WIOD database includes annual world input-output tables with a disaggregation of 35 economic sectors, with a complete and harmonized assessment of bilateral sector-country flows of intermediate and final goods. Moreover, the WIOD database includes a comprehensive set of economic and environmental accounts. By following the definition of Hoekstra (2003), water usage is split into blue water (from irrigation), green water (rainfall) and grey water (polluted).

Methodology and preliminary results

In this section we discuss some interesting results concerning two important indexes of sustainability together with ongoing research activities.

Virtual water trade balance (country-specific)

The virtual water trade balance provides a first insight about the ability of each country to satisfy its internal demand by using water resources available within its boundaries (that is if it is a net exporter), or whether a country is in debt because it must import virtual water from abroad. In all cases, during the time window considered, it is possible to observe that China, India and Canada are the top exporters of virtual water, with China that is becoming more and more important, doubling its export between 1995 and 2009.

Among the most important importers we can find the US, Japan, Germany and United Kingdom. This imbalance is remarkable if we consider that these countries cover only 10% of the world population. Surprisingly, Russia is recently becoming a net importer after a long period in which it has been an important net exporter of Virtual Water.

We have computed the degree of international dependence for each sector of each country, by comparing the Leontief multipliers within a country with the multipliers due to international trade of intermediate goods. As a result, we observe that the role of international trade is becoming one of the key drivers the increase of Virtual Water. At a first sight, it seems that the smallest economies (especially small countries in Eastern Europe) are rapidly opening their economies to international trade, thus becoming increasingly dependent on Virtual Water embodied in imported goods. The same happens at the sectoral level: the two most important sectors in terms of water footprint consumption (Energy and Agriculture) have seen a substantial increase in absolute and relative terms of international trade and related Virtual Water.

Structural decomposition analysis (SDA)

The aim of structural decomposition analysis is to quantify the driving force behind the growth of Virtual Water trade and consumption. By using input-output tables expressed in constant prices (base year is 1995), we investigate the structure of trade, both in intermediate and final goods. We address the following specific research questions: does the evolution of Virtual Water trade differs across countries? Which is the relative and absolute contribution of technological change, international trade, resource use intensity and final demand (level and

composition) to Virtual Water patterns? The SDA allows to disentangle and to compute the effect of the main forces which lead economic outcomes and their effect on environmental resources usage. Preliminary results show that while water use intensity only partially mitigated the water-increasing effect of final demand. Moreover, we observe an increasing role of imported Virtual Water as opposed to domestic Virtual Water.

Network theory

From the dynamic elaboration we aim at investigating the convergence (if any) of the technological structure of the economy of each country with the respect of the world average. More specifically, we may think to a sort of club convergence in which some group of countries specializes in the production of the same goods, in a sort of Ricardian (comparative advantage) or Heckscher-Ohlin (factor endowment) framework. This last point together recall the concept of community structure and assortativity. The aim is to improve previous studies which found that the number of links in the Virtual Water trade is doubled from 1986 to 2010. Other studies consider the time-varying community structure of the virtual water network and groups of countries with dense internal connections. Surprisingly geographic proximity only partly explains the community structure of virtual water trade.