EXTENDED ABSTRACT

Title: An Environmental Application of the Multi-Dynamic Interregional Input-Output Shift-Share to Water Use Worldwide

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Abstract:

In the coming decades, increasing world population and economic development will lead to further increase in food consumption that will significantly impact water supply. At the same time, fragmented production processes and complex trade relationships due to globalization have complicated the monitoring of water used through global supply chains and hence the assessment of the driving factors behind its use. To better understand the key drivers of regional water use worldwide, adapted to the new context of growing influence of global value chains, we present the first application of the new Multi-Dynamic Interregional Input-Output Shift-Share decomposition to the environmental scope. The MDIOSS can determine whether the growth of water use is mostly related to the national context or is a consequence of the increment in the other continental countries and/or global international trade flows. MDIOSS allows us to calculate explicitly the degree of sensitivity of the water use growth by a production sector to the growth of its entire supply-chain linkages while distinguishing these linkages between three geographical units: country of interest, rest of the countries in the same continent and rest of the world. The methodology is illustrated on the agri-food sectors of 189 countries worldwide over 2000-2015.

Keywords: shift-share analysis, Multi Regional Input Output Tables (MRIO), water footprint.

JEL codes: **D57** Input–Output Tables and Analysis; **F18** Trade and Environment; **Q25** Water; **R11** Regional Economic Activity: Growth, Development, Environmental Issues, and Changes.

1. Introduction

Shift-share (SS) is a widely-used, exploratory, technique that uncovers the key drivers of the growth rate of a sector in a specific location. Shift-share does not establish or assume causality. This method was first applied by MacDougal (1940), Jones (1940) and Creamer (1943), although its popularization has been attributed to Dunn (1960). Its main objective is to compare the economic performance of various spatial units and sectors. The basic approach consists in decomposing growth into three components: the national effect captures the impact of national trends, the industry-mix effect measures the deviation from national trends and the competitive effect (also called regional shift) quantifies the regional competitiveness. The popularity of this technique comes from its minimum data requirement as well as its simplicity and ease of interpretation (Dinc & Haynes 1998; Haynes & Machundra, 1987). In this regard, the shift-share method reveals the distance between the observed regional performance and the benchmark, often set to the national average level (Lahr & Dietzenbacher, 2017). Any difference indicates that a region or sector displays a comparative strength or weakness compared to the nation.

However, this method has been criticized for several reasons, hence generating many reformulations of the original decomposition (see e.g. Artige & van Neuss, 2014; Arcelus, 1984; Cunningham, 1969; Esteban-Marquillas, 1972; Houston, 1967; Rosenfeld, 1959). Another part of the literature has tried to overcome the shortcomings produced by the sensitivity of the results to the level of industry aggregation, regional disaggregation and period under study (Barff & Knight, 1988; Haynes & Dinc 1997; Haynes & Machunda 1987; Markusen et al., 1991) while a recent contribution by Ruault and Schaeffer (2020) offers to account for the number of industries that integrate the economic structure of a country/region, the emergence of new sectors and the rise or collapse of some industries in the analysis. Some of the most recent contributions focus on the use of other geographical units than the nation a region belongs to for the definition of the benchmark (see, among others, Loveridge and Selting, 1998; Sihag and McDonough, 1989). Among them, Nazara and Hewings (2004) highlight that the shift-share components are unlikely to be spatially independent; as a result, they propose the first spatial shift-share decomposition. In this approach, they use the average in the neighborhood of a spatial unit as the benchmark. Several works have applied spatial SS to different samples over the years (Espa et al., 2014; Hareth et al., 2013; Matlaba et al., 2014; Montanía et al., 2020; Ramajo & Márquez, 2008). In this context, geographical proximity acts as a proxy for endogenous factors such as face-to-face interactions (McCann, 2007; Rallet & Torre, 1999), the reduction of transportations costs (Sonn and Storper, 2008), and the decrease of commuting to work (Knoben & Oerlemans, 2006). However, spatial proximity is not the only way to model how two or more economies relate to each other.

A deeper understanding of interregional interaction took place when Márquez et al. (2009) introduced a shift-share approach whereby the sectoral linkages that each sector has developed with other sectors within the national borders are accounted for. These industrial spillovers are caused by regional specialization (Marshall, 1920; Arrow, 1962; Romer, 1986; Glaeser et al., 1992) or by diversified regional production structures (Jacobs 1969), hence their presence in SS allows the user to identify the sources of the geographical concentration of industries (see Ellison & Glaeser, 1997; Fujita & Thisse, 1996; Krugman, 1991). Despite the usefulness of this type of regional links, the approach presented by Márquez et al. (2009) disregards the role of the sectoral links outside the country under study. In addition, their setting considers the sectoral relationships as static, which is a difficult assumption to match with reality since the structural transformation of an economy is a widely recognized phenomenon (Mesnard, 1992; Skolka, 1989).

As such, Montanía and Dall'erba filled these gaps by offering the first multi-dynamic input-output shift-share analysis (MDIOSS, a.k.a. Montanía-Dall'erba Input-Output ShiftShare). It allows to consider, first, the intersectoral relationships between a spatial unit and any other unit it trades with, no matter the distance that separates them. In addition, unlike a neighborhood structure that does not change with time, sectoral linkages evolve continually. Therefore, MDIOSS offers exploratory information about the potential drivers of economic growth, adapted to the new context of globalization, trade liberalization, and growing influence of global value chains (Lahr & Dietzenbacher, 2017; Serrano & Dietzenbacher, 2010).

Simultaneously, in recent years, due attention has been paid to the effects of the growing importance of international trade on water. In the case of products containing virtual water (i.e., requiring water for their production), international trade is a means of transferring water resources between regions. Besides, food trade may help save water on a global scale by encouraging exchanges of virtual water from highly productive countries to less productive countries.

Consequently, in this paper, we apply the first environmental MDIOSS on which the variable of interest is the growth rate of total water use requirements $W_{i,k}$ associated to sector k of the world country i between 2000 and 2015.

2. Model

The formulation of environmental-MDIOSS is as follows:

$$w_{i,k}W_{i,k} = (w_{REU15,k} - w_{i,k})W_{i,k} + (w_{i,k} - w_{ROW,k})W_{i,k} + (w_{ROW,k} - w_{REU15,k})W_{i,k} =$$

$$\left(\sum_j LD^t_{k,j}\, w_{i,j}\right)W_{i,k} + \left(w_{i,k} - \sum_j LD^t_{k,j}\, w_{i,j}\right)W_{i,k} +$$

$$\left(\sum_j LREU15^t_{k,j}\, w_{REU15,j} - \sum_j LD^t_{k,j}\, w_{i,j}\right)W_{i,k} + \left(\sum_j GLREU15_{k,j}W_{i,k} - \sum_j GLD_{k,j}W_{i,k}\right) +$$

$$\left(\sum_j LD^t_{k,j}\, w_{i,j} - \sum_j LROW^t_{k,j}\, w_{ROW,j}\right)W_{i,k} + \left(\sum_j GLD_{k,j}W_{i,k} - \sum_j GLROW_{k,j}W_{i,k}\right) +$$

$$\left(\sum_j LROW^t_{k,j}\, w_{ROW,j} - \sum_j LREU15^t_{k,j}\, w_{REU15,j}\right)W_{i,k} + \left(\sum_j GLROW_{k,j}W_{i,k} - \sum_j GLREU15_{k,j}W_{i,k}\right)$$

= SDE+DSE+ ISE_RCC_DOM + ITE_RCC_DOM+ISE_DOM_ROW+ ITE_DOM_ROW+ ISE_ROW_RCC+ ITE_ROW_RCC

where $w_{i,j}$, $w_{REU15,j}$ and $w_{ROW,j}$ are the growth rates of water use requirements of sector j at the domestic, rest of the continent (RCC) and ROW levels respectively between 2000 and 2015.

- The first component is the sectoral domestic effect (SDE). It represents the weighted average of the growth rates of total water use by the sectors that have linkages with sector k at the domestic level.
- The second component is the domestic sectoral shift effect (DSE). It displays the comparative advantages (or disadvantages) of sector k of country i with respect to the national sectors it trades with (in average terms).
- The third component is the rest of the continent to domestic effect (growth rates difference ISE_RCC_DOM). It compares the water use of the sectors with linkages to sector k in terms of two geographical levels: rest of the continent a country belongs to and the country i.
- The fourth component is the rest of the continent to domestic effect (change in economic structure ITE_RCC_DOM). It captures the difference in the growth of the sectoral linkages of sector k in the rest of the continent a country belongs to with the domestic ones.

- The fifth component is the domestic to ROW effect (growth rates difference ISE_DOM_ROW). It compares the outputs of the sectors with linkages to sector k in terms of two geographical levels: the country i and ROW.
- The sixth component is the domestic to ROW effect (change in economic structure ITE_DOM_ROW). It corresponds to the difference in the growth of the sectoral linkages of sector k in country i with that in the ROW.
- The seventh component is the ROW to Rest of the Continent effect (growth rates difference ISE_ROW_RCC). It is the difference in the outputs of the sectors with linkages to sector k in the ROW vs. in the rest of the continent a country belongs to.
- The eight component is the ROW to Rest of the Continent effect (change in economic structure ITE_ROW_RCC). It determines whether the links of sector k with sectors from ROW change faster (slower) than those with sectors from the rest of the continent a country belongs to.

3. Data

The analysis was carried out applying the environmental-MDIOSS on a set of annual input-output tables expressed at basic prices for the 2000–2015 period and obtained from the Eora 26 MRIO database developed by Lenzen et al. (2012). They are harmonized time series of 26 sectors and 189 economies worldwide. Compared with other MRIO databases such as GTAP (Peters et al., 2011), WIOD (Dietzenbacher et al., 2013), or EXIOBASE (Tukker et al., 2013), Eora is the only one provides with a high country coverage, high sector resolution, and a full time-series. To perform the SDA, the Eora MRIO tables were deflated from their current prices to constant 2015 US dollars using the procedure of double deflation (Lan et al., 2016). To measure water use, a set of satellite environmental accounts for the same period as the MRIO tables are available in Eora 26.