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GLOBAL WATER IN A GLOBAL WORLD: A LONG TERM STUDY ON AGRICULTURAL VIRTUAL WATER FLOWS IN THE WORLD

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Keywords: Virtual water trade, Decomposition Analysis, Global environmental change

JEL codes: F18, N50, N70, Q25, Q27

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1. Introduction

Food production has experienced a marked increase during the last fifty years (FAO, 2013; Rask and Rask, 2011). Together with it, commercial exchanges of agricultural and food products have gone through a great growth in the past half century (Rask and Rask, 2011; Serrano and Pinilla, 2010, 2011a). This globalisation process has involved not only an important trade of commodities, but also huge exchanges of natural resources embodied in these goods (Schmitz et al., 2012). Consequently, people consuming products from other parts in the word, are at the same time consuming water, biomass or land from distant places. Therefore, a mismatch between the responsibilities of producer and consumer regions appears.

The relationship between the use of natural resources and economic growth has been widely examined in recent years. In this line, today there are many studies that assess the path followed by timber (Iriarte-Goñi and Ayuda, 2008, 2012), land (Kohlheb and Krausmann, 2009; Krausmann et al., 2013; Weinzettel et al., 2013), biomass or minerals (Krausmann et al., 2009). Many of them are socio-metabolism studies that try to account for exchanges of materials and energy between societies and their natural environment (Fischer-Kowalski and Hüttler, 1998).

As for water, a large number of studies have been carried out over the last decade. They consider water not only as a local, but also as a global resource since it is virtually transferred embodied in products that are internationally exchanged. In this framework, the concept of virtual water first defined by Allan (1997) is the volume of water necessary for the production of a commodity. Very close to it, the water footprint is an indicator of freshwater use that looks at both direct and indirect water use of a consumer or producer (Hoekstra et al., 2011). These studies tend to distinguish between green and blue water. Green water is the rainwater evaporated as a result of the production of a commodity and blue water is surface or groundwater evaporated during a production process (Hoekstra and Chapagain, 2008). Both are interrelated in the hydrological system, however blue water is said to have higher opportunity costs, as it can be reallocated among the different users (Yang et al., 2007). Virtual water has been methodologically studied from the top-down and bottom-up approaches. The former adopts environmental input-output analysis to obtain virtual water and water footprints by accounting for regional, national or/and global supply chains (Feng et al., 2012; Steen-Olsen et al., 2012). The latter gets footprints on the basis of virtual water content of internationally traded goods and services determined from detailed process data. In this paper we will use the bottom-up methodology that according to Feng et al. (2011) "has become one of the most popular approaches in water footprinting studies due to its simplicity and relatively good data availability, concentrating mainly on agricultural and food products". Whereas many of these studies focus on the short term, to our knowledge there are no papers addressing global virtual water trade flows in the long run. From our viewpoint, the long term approach is essential to assess the way that water displacements have occurred in history, addressing the trajectories and feedbacks lying behind the relationship between societies and water resources. As Schandl and Schulz (2002) said, an environmental history perspective "may enable society to consciously intervene in these natural relations and might even eventually foster our understanding of sustainability". This seems particularly important in the period studied, when the second globalisation took place. This long term process has entailed an outstanding economic and commercial integration that has resulted in growing exchanges of factors and products that embody large volumes of water. In this context, it is essential to examine the role played by the second globalisation in the link between growth and water resources at a global level.

Therefore, this paper assesses the trends in virtual water transfers in the world from 1965 to 2010, a period of intense internationalization that meant important environmental impacts. To that aim, we will analyze global trends paying special attention to those areas that exert the largest pressures on their domestic water resources to be consumed in other parts of the world, studying the amount and direction of global virtual water flows. We will use the bottom-up approach, that will allow us to study global water displacements of agricultural and food products in a highly disaggregated way. Besides, we will obtain and quantify those factors that may lie behind the path followed by virtual water imports and exports. By means of a Decomposition Analysis (DA), trends in water exchanges will be explained on the basis of changes in the volume of trade, in the trade composition by products, in the origin of flows as well as in the main commercial countries concerning agricultural and food products.

We will utilize bilateral trade data given by United Nations Statistics Division (UN, 2013) and coefficients on water use intensity provided by Mekonnen and Hoekstra (2011, 2012). From them, we will obtain the volume of water exchanged between world regions and countries throughout the period 1965-2010.

The following section addresses the main methodological aspects and explains the data. Section 3 deals with the main findings of the work. Section 4 goes with the discussion of the results and section 5 ends with the main conclusions.

2. Methodology and Data

2.1. Methodological aspects

As a first step, we estimate virtual water trade flows following the method proposed by Hoekstra and Hung (2005). Thus, virtual water exports of country *c* in year *t* are obtained as:

$$VWX(c,t) = \sum_{p} d_p^c(c,p,t) * e_p^c(c,p,t) \quad (1)$$

Being e_p^c the quantity of product *p* exported (Tons) and d_p^c a coefficient indicating the volume of water necessary to produce a ton of each commodity in the exporting country, i.e., water intensity (m^3/Ton). d_p^c will distinguish between green or blue water.

Virtual water imports are the sum of the water embodied in the imported goods coming from country *z*.

$$VWM(c,t) = \sum_{pz} d_p^Z(z,p,t) * m_p^z(z,p,t) \quad (2)$$

With m_p^z being the bilateral import flow from country *z* to country *c* (Tons) and d_p^Z representing the water required in country z to produce *p* (m^3/Ton). Thus, calculating the difference between virtual water exports and virtual water imports we get the virtual water trade balance for each country *c*:

$$VWB(c,t) = VWX(c,t) - VWM(c,t) \qquad (3)$$

Secondly, we apply a Decomposition Analysis (DA) to obtain the factors driving virtual water exports and imports changes. Embodied water in exports can be explained on the basis of four elements: water content per unit of crop, product composition of trade, country shares and scale, obtaining:

$$VWX(c,t) = \sum_{p} w_{cpt} \cdot \frac{e_{cpt}}{e_{ct}} \frac{e_{ct}}{e_t} e_t \qquad (4)$$

The former expression in matrix form yields:

$$VWX(c,t) = \mathbf{w}'_{\mathbf{ct}} \mathbf{f}_{\mathbf{ct}} s_{ct} e_t \qquad (5)$$

With $\mathbf{w}'_{\mathbf{ct}}$ being a row vector of the water intensity per unit of product in m^3/\$ in country c, $\mathbf{f}_{ct}$ is a vector showing the share that each product represents in total exports of country *c* in period *t*. s_{ct} is a scalar with the percentage of the country in total exports and e_t is the total value of exports in the world in year *t* (in dollars).

For the whole world economy, we would write:

$$VWX(t) = \mathbf{w}'_{\mathbf{t}} \mathbf{X}_{\mathbf{t}} \mathbf{s}_{\mathbf{t}} e_t \qquad (6)$$

Being $\mathbf{w}'_{\mathbf{t}}$ a vector of water intensities per product and country, $\mathbf{X}_{\mathbf{t}}$ a matrix of the share of product exports per country, $\mathbf{s}_{\mathbf{t}}$ is a vector showing the country shares in total world exports and e_t the total volume of world exports.

Virtual water imports can be explained on the basis of five drivers; water intensities, the origin of flows, product composition, country shares and scale of trade.

$$VWM(c,t) = \sum_{p,z} w_{cpzt} \cdot \frac{m_{cpzt}}{m_{cpt}} \cdot \frac{m_{cpt}}{m_{ct}} \frac{m_{ct}}{m_t} m_t \qquad (7)$$

or, in matrix form,

$$VWM(c,t) = \mathbf{w}'_{\mathbf{czt}}\mathbf{M}_{\mathbf{czt}}\mathbf{b}_{\mathbf{ct}}r_{ct}m_t \qquad (8)$$

being $\mathbf{w}'_{\mathbf{czt}}$ a row vector of the embodied water per product in each of the countries *z* from which country *c* imports, measured in $m^3/\$$. $\mathbf{M}_{\mathbf{czt}}$ is a matrix that includes, for each product *p*, the percentage imported by *c* from each country *z*. Moreover, $\mathbf{b}_{\mathbf{ct}}$ is a vector of product import composition in country *c*, r_{ct} is a scalar showing the participation of country *c* in the world imports and m_t is a scalar with the total value of imports in the world in year *t* (in dollars).

Similarly, for the world economy, the total volume of water imports can be expressed as follows:

$$VWM(t) = \mathbf{w}_{\mathbf{t}}'\mathbf{M}_{\mathbf{t}}\mathbf{P}_{\mathbf{t}}\mathbf{r}_t m_t \qquad (9)$$

Being $\mathbf{w}'_{\mathbf{t}}$ a vector of water intensities per product and country, $\mathbf{M}_{\mathbf{t}}$ a matrix of the share of imports (per country of origin and per product, with main diagonal blocks equal to cero), $\mathbf{P}_{\mathbf{t}}$ is a matrix of product composition of imports (for each country), $\mathbf{r}_t$ is a vector of import country shares in total world imports and m_t is the total volume of world imports.

Note that while $VWX(c,t)$ differ from $VWM(c,t)$ at the country level, $VWX(t) = VWM(t)$ holds for the whole world economy, so aggregated water balance is zero from this perspective.

The above equations can be handled at the country level or at the world level. Similarly, it is possible to derive by-product expressions for water exports and imports on the basis of the above developments.

Departing from equations (5) and (8), we utilize the DA. This approach tries to separate a time trend of an aggregated variable into a group of driving forces that can act as accelerators or retardants (Dietzenbacher and Los, 1998; Hoekstra and van den Bergh, 2002; Lenzen et al., 2001).

In a discrete schema, when we try to measure the changes in the dependent variable between two periods, *t-1* and *t*, there are different ways of solving this expression by way of exact decompositions, which leads the well-known problem of non-uniqueness of DA solution. In our case, decomposition is based on five factors for imports and fours factors for exports; therefore we can obtain the following 5! and 4! exact decompositions respectively. In practice, as a "commitment solution", the average of two polar solutions is considered (Dietzenbacher and Los, 1998).

Therefore, the polar decompositions of (5) can be written as follows:

$$\Delta VWX(c) = \Delta \mathbf{w}'_{\mathbf{c}}\mathbf{f}_{\mathbf{ct}}s_{ct}e_t + \mathbf{w}'_{\mathbf{ct-1}}\Delta\mathbf{f}_{\mathbf{c}}s_{ct}e_t + \mathbf{w}'_{\mathbf{ct-1}}\mathbf{f}_{\mathbf{ct-1}}\Delta s_c e_t + \mathbf{w}'_{\mathbf{ct-1}}\mathbf{f}_{\mathbf{ct-1}}s_{ct-1}\Delta e \qquad (10)$$

$$\Delta VWX(c) = \Delta \mathbf{w}'_{\mathbf{c}}\mathbf{f}_{\mathbf{ct-1}}s_{ct-1}e_{t-1} + \mathbf{w}'_{\mathbf{ct}}\Delta\mathbf{f}_{\mathbf{c}}s_{ct-1}e_{t-1} + \mathbf{w}'_{\mathbf{ct}}\mathbf{f}_{\mathbf{ct}}\Delta s_c e_{t-1} + \mathbf{w}'_{\mathbf{ct}}\mathbf{f}_{\mathbf{ct}}s_{ct}\Delta e \qquad (11)$$

Furthermore, based on (8) we get the two polar decompositions of imports, which yields:

$$\Delta VWM(c) = \Delta \mathbf{w}'_{\mathbf{cz}}\mathbf{M}_{\mathbf{czt}}\mathbf{b}_{\mathbf{ct}}r_{ct}m_t + \mathbf{w}'_{\mathbf{czt-1}}\Delta\mathbf{M}_{\mathbf{cz}}\mathbf{b}_{\mathbf{ct}}r_{ct}m_t + \mathbf{w}'_{\mathbf{czt-1}}\mathbf{M}_{\mathbf{czt-1}}\Delta\mathbf{b}_{\mathbf{c}}r_{ct}m_t + \mathbf{w}'_{\mathbf{czt-1}}\mathbf{M}_{\mathbf{czt-1}}\mathbf{b}_{\mathbf{ct-1}}\Delta r_c m_t + \mathbf{w}'_{\mathbf{czt-1}}\mathbf{M}_{\mathbf{czt-1}}\mathbf{b}_{\mathbf{ct-1}}r_{ct-1}\Delta m \qquad (12)$$

$$\Delta VWM(c) = \Delta \mathbf{w}'_{\mathbf{cz}}\mathbf{M}_{\mathbf{czt-1}}\mathbf{b}_{\mathbf{ct-1}}r_{ct-1}m_{t-1} + \mathbf{w}'_{\mathbf{czt}}\Delta\mathbf{M}_{\mathbf{cz}}\mathbf{b}_{\mathbf{ct-1}}r_{ct-1}m_{t-1} + \mathbf{w}'_{\mathbf{czt}}\mathbf{M}_{\mathbf{czt}}\Delta\mathbf{b}_{\mathbf{c}}r_{ct-1}m_{t-1} + \mathbf{w}'_{\mathbf{czt}}\mathbf{M}_{\mathbf{czt}}\mathbf{b}_{\mathbf{ct}}\Delta r_c m_{t-1} + \mathbf{w}'_{\mathbf{czt}}\mathbf{M}_{\mathbf{czt}}\mathbf{b}_{\mathbf{ct}}r_{ct}\Delta m \qquad (13)$$

Taking the average of (10) and (11) we obtain (14)

$$\Delta VWX(c) = \frac{\Delta \mathbf{w}'_{\mathbf{c}}\mathbf{f}_{\mathbf{ct}}s_{ct}e_t + \Delta \mathbf{w}'_{\mathbf{c}}\mathbf{f}_{\mathbf{ct-1}}s_{ct-1}e_{t-1}}{2} + \frac{\mathbf{w}'_{\mathbf{ct-1}}\Delta\mathbf{f}_{\mathbf{c}}s_{ct}e_t + \mathbf{w}'_{\mathbf{ct}}\Delta\mathbf{f}_{\mathbf{c}}s_{ct-1}e_{t-1}}{2} + \frac{\mathbf{w}'_{\mathbf{ct-1}}\mathbf{f}_{\mathbf{ct-1}}\Delta s_c e_t + \mathbf{w}'_{\mathbf{ct}}\mathbf{f}_{\mathbf{ct}}\Delta s_c e_{t-1}}{2} + \frac{\mathbf{w}'_{\mathbf{ct-1}}\mathbf{f}_{\mathbf{ct-1}}s_{ct-1}\Delta e + \mathbf{w}'_{\mathbf{ct}}\mathbf{f}_{\mathbf{ct}}s_{ct}\Delta e}{2} \qquad (14)$$

Proceeding the same way with (11) and (13) gives equation (15)

$$\Delta VWM(c) = \frac{\Delta \mathbf{w}'_{cz}\mathbf{M}_{czt}\mathbf{b}_{ct}r_{ct}m_t + \Delta \mathbf{w}'_{cz}\mathbf{M}_{czt-1}\mathbf{b}_{ct-1}r_{ct-1}m_{t-1}}{2} + \frac{\mathbf{w}'_{czt-1}\Delta\mathbf{M}_{cz}\mathbf{b}_{ct}r_{ct}m_t + \mathbf{w}'_{czt}\Delta\mathbf{M}_{cz}\mathbf{b}_{ct-1}r_{ct-1}m_{t-1}}{2} + \frac{\mathbf{w}'_{czt-1}\mathbf{M}_{czt-1}\Delta\mathbf{b}_{c}r_{ct}m_t + \mathbf{w}'_{czt}\mathbf{M}_{czt}\Delta\mathbf{b}_{c}r_{ct-1}m_{t-1}}{2} + \frac{\mathbf{w}'_{czt-1}\mathbf{M}_{czt-1}\mathbf{b}_{ct-1}\Delta r_c m_t + \mathbf{w}'_{czt}\mathbf{M}_{czt}\mathbf{b}_{ct}\Delta r_c m_{t-1}}{2} + \frac{\mathbf{w}'_{czt-1}\mathbf{M}_{czt-1}\mathbf{b}_{ct-1}r_{ct-1}\Delta m + \mathbf{w}'_{czt}\mathbf{M}_{czt}\mathbf{b}_{ct}r_{ct}\Delta m}{2} \quad (15)$$

Accordingly, we obtain the following effects that explain changes in virtual water flows:

- Scale effect, which quantifies how much of the change in virtual water flows is explained by changes in the volume of exports or imports. It yields (16) for exports and (17) for imports:

$$SE_x(c) = \frac{\mathbf{w}'_{ct-1}\mathbf{f}_{ct-1}s_{ct-1}\Delta e + \mathbf{w}'_{ct}\mathbf{f}_{ct}s_{ct}\Delta e}{2} \quad (16)$$

$$SE_m(c) = \frac{\mathbf{w}'_{czt-1}\mathbf{M}_{czt-1}\mathbf{b}_{ct-1}r_{ct-1}\Delta m + \mathbf{w}'_{czt}\mathbf{M}_{czt}\mathbf{b}_{ct}r_{ct}\Delta m}{2} \quad (17)$$

- Composition effect, which measures the impact of changes of the product composition of trade flows in each country. It is represented by (18) for exports and (19) for imports:

$$CE_x(c) = \frac{\mathbf{w}'_{ct-1}\Delta\mathbf{f}_c s_{ct}e_t + \mathbf{w}'_{ct}\Delta\mathbf{f}_c s_{ct-1}e_{t-1}}{2} \quad (18)$$

$$CE_m(c) = \frac{\mathbf{w}'_{czt-1}\mathbf{M}_{czt-1}\Delta\mathbf{b}_c r_{ct}m_t + \mathbf{w}'_{czt}\mathbf{M}_{czt}\Delta\mathbf{b}_c r_{ct-1}m_{t-1}}{2} \quad (19)$$

- Trade share effect, which quantifies the effect that variations in the weight of countries in global trade have in virtual water trends. It is given by (20) for exports and (21) for imports:

$$TSE_x(c) = \frac{\mathbf{w}'_{ct-1}\mathbf{f}_{ct-1}\Delta s_c e_t + \mathbf{w}'_{ct}\mathbf{f}_{ct}\Delta s_c e_{t-1}}{2} \quad (20)$$

$$TSE_m(c) = \frac{\mathbf{w}'_{\mathbf{czt-1}}\mathbf{M}_{\mathbf{czt-1}}\mathbf{b}_{\mathbf{ct-1}}\Delta r_c m_t + \mathbf{w}'_{\mathbf{czt}}\mathbf{M}_{\mathbf{czt}}\mathbf{b}_{\mathbf{ct}}\Delta r_c m_{t-1}}{2} \quad (21)$$

- Localization effect, which indicates to what extent changes in the countries from importers buy each product affect virtual water flows. It only exists for virtual water imports and is given by (22).

$$LE_m(c) = \frac{\mathbf{w}'_{\mathbf{czt-1}}\Delta\mathbf{M}_{\mathbf{cz}}\mathbf{b}_{\mathbf{ct}}r_{ct}m_t + \mathbf{w}'_{\mathbf{czt}}\Delta\mathbf{M}_{\mathbf{cz}}\mathbf{b}_{\mathbf{ct-1}}r_{ct-1}m_{t-1}}{2} \quad (22)$$

- Intensity effect, which identifies the contribution of changes in water intensities to changes in virtual water trade flows. It is given by (23) for exports and (24) for imports:

$$IE_x(c) = \frac{\Delta\mathbf{w}'_{\mathbf{c}}\mathbf{f}_{\mathbf{ct}}s_{ct}e_t + \Delta\mathbf{w}'_{\mathbf{c}}\mathbf{f}_{\mathbf{ct-1}}s_{ct-1}e_{t-1}}{2} \quad (23)$$

$$IE_m(c) = \frac{\Delta\mathbf{w}'_{\mathbf{cz}}\mathbf{M}_{\mathbf{czt}}\mathbf{b}_{\mathbf{ct}}r_{ct}m_t + \Delta\mathbf{w}'_{\mathbf{cz}}\mathbf{M}_{\mathbf{czt-1}}\mathbf{b}_{\mathbf{ct-1}}r_{ct-1}m_{t-1}}{2} \quad (24)$$

2.2. Data

Trade data on agricultural and food products are taken form United Nations Statistics Division (UN, 2013) at the four-digit level of the Standard International Trade Classification, SITC, revision 1. Our sample considers 136 products and 104 countries, accounting for approximately 85% of agricultural and food commercial exchanges in the world during these years. DA requires trade data in monetary units. Thus, we calculate world prices of each product in 1985 and express trade data at constant 1985 dollars.

Water intensities stem from Mekonnen and Hoekstra (2011, 2012). They estimate water coefficients following the approach developed by Allen et al. (1998) and Hoekstra et al. (2009), i.e., dividing crop water use (green or blue) obtained as evapotranspiration (ET) under non optimal conditions by the crop yield. While climatic and crop characteristics (ET) can be assumed to be constant over time, technological advances such as irrigation or improvements in seeds involved notable yield improvements that could have affected water intensities from 1965 to 2010. Thus, in line with Dalin et al. (2012); Konar et al. (2013), water coefficients have been adapted varying depending on national yield series as follows:

$$w_{cpt} = w_{cp}\frac{Y_{cp}}{Y_{cpt}} \qquad (23)$$

With w_{cpt} being the water coefficient for each product in the period of analysis (t from 1965 to 2010), w_{cp} is the crop or livestock water intensity given by Mekonnen and Hoekstra (2011, 2012).Y_{cp}represents the average yield of the reference period (1996-2005) and Y_{cpt} are the annual product yields for each specific year studied. The hypothesis underlying this approach is that technological developments have influenced crop and livestock yields in the long term, also affecting water consumption per ton. Data on crop and livestock yields from 1965 to 2010 have been taken from Food and Agriculture Organisation of the United Nations (FAO, 2013).

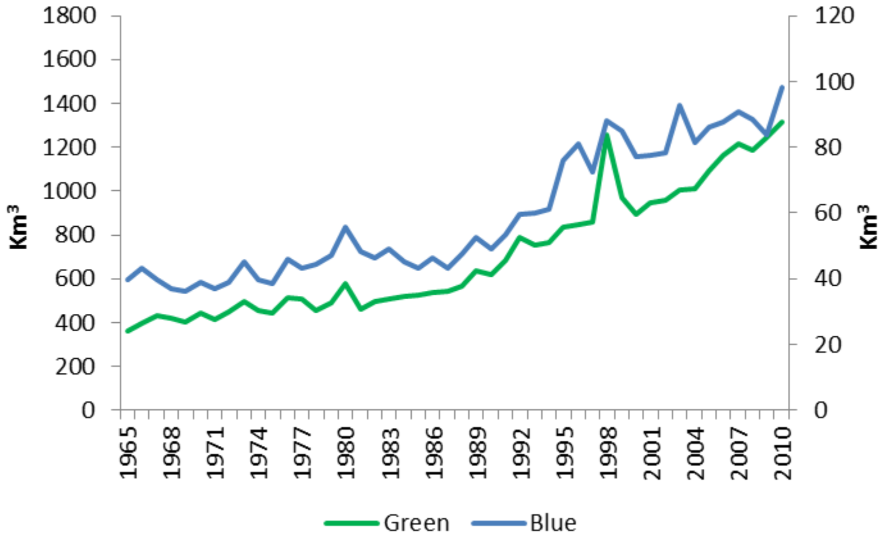
3. Results

3.1. Global virtual water flows assessment

Globally, virtual water flows experienced a continuous growth from 1965 to 2010, i.e., the volume of water embodied in agricultural and livestock products exchanged internationally through trade went from 403 km^3 in 1965 to 1,415 km^3 in 2010, growing at an average annual growth rate of 2.7%. This increase was particularly intense from 1980, above all during the nineties, when global virtual water trade flows rose by 3.8% every year on average. As Figure 1 shows, green water was the most important component in total virtual water, since blue water only represented 8% over global water consumption on average. Besides, exchanges of green water depicted a most vigorous increase, growing at 2.8% every year, opposite to blue water that rose at 2.7% annually.

This growing pattern was similar all over the world, with the exception of Africa and The Former Soviet Union where the trajectory was quite erratic. Nevertheless the contribution of each region to virtual water exports and imports rather diverges (see Table 1).

Figure1: Global virtual water flows, 1965-2010 (km^3)



Green water is referred to the left axis. Blue water is referred the right axis.

On the whole, the percentages representing the share of the world regions on exports and imports, and its tendency, tend to be similar to those resulting when analyzing values, i.e., in monetary units (Serrano and Pinilla, 2011a). Obviously, the figures are approximate, given the changes in the composition of trade by product and the differences of using prices or water intensities. The largest exporter of blue water was North America all over the period, followed by Europe or Asia and Pacific. The importance of the U.S. as an exporter of agri-food products and the enormous development of its irrigation system from the nineteenth century explain the high virtual water exports of North America. The intense intra-European trade of agricultural and food products, clearly influenced by the process of economic integration, together with its growing share on processed and high value added agri-food exports could lie behind the importance and growing weight of Europe in global virtual water trade (Serrano and Pinilla, 2011b). In the case of green water, Latin and North America appear as the most representative exporters, accounting for a share of 26.6% and 25.2% respectively. The downward trend in the Latin American share was caused by its poor agricultural exports performance from the fifties until the last decade of the twentieth century.

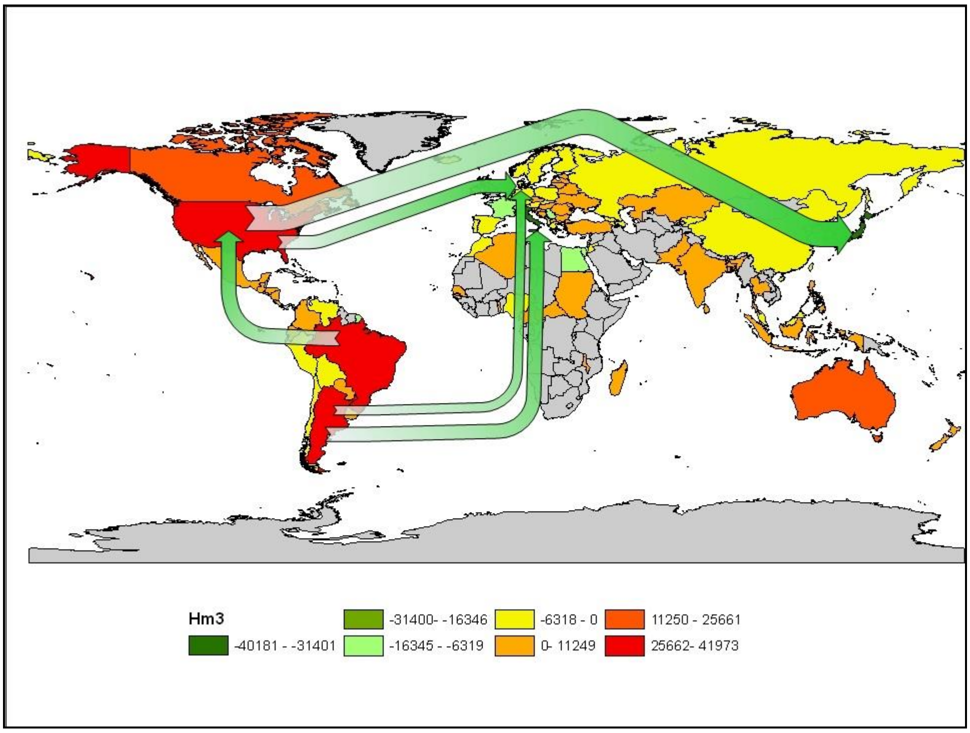
Looking at imports, Europe and Asia and Pacific were the largest buyers of both blue and green virtual water during the period considered. Europe supposed more than 50% of water imports in the world during the sixties but tended to decrease its importance, reaching a share of 36% today. This is related to the implementation of the Common Agricultural Policy that involved an increase in the agricultural protectionism and a drop in the weight of European agricultural imports (Pinilla and Serrano, 2009). On the contrary, Asia and Pacific used to increase its significance in blue virtual water imports. The very strong economic growth in Asian countries since the eighties, and especially in China, explain this rising importance in global virtual water imports.

Table 1: Average contribution of world regions to virtual water exports and imports (%)

	1965-1969	1970-1979	1980-1989	1990-1999	2000-2010	1965-1969	1970-1979	1980-1989	1990-1999	2000-2010
			Blue water exports					**Green water exports**		
Africa	16.4	12.4	7.9	4.9	5.5	4.5	4.1	3.1	2.1	1.4
North America	26.8	35.9	34.5	30.8	30.4	24.7	30.7	28.5	24.8	22.1
Asia and Pacific	17.9	16.8	20.6	19.7	20.8	12.9	11.8	14.5	17.9	18.4
Europe	15.9	18.8	22.5	22.1	22.6	17.2	17.4	20.8	20.1	18.9
Former Soviet Union	0.5	0.3	0.2	6.0	3.4	2.0	0.7	0.2	5.8	6.3
Latin America	17.7	11.6	8.4	9.5	10.9	30.7	26.3	24.6	24.5	28.3
Oceania	4.8	4.2	5.8	7.1	6.4	7.9	9.0	8.4	4.7	4.5
Total	100	100	100	100	100	100	100	100	100	100
			Blue water imports					**Green water imports**		
Africa	3.0	6.1	8.5	5.3	6.4	3.4	4.8	6.4	5.2	6.4
North America	12.2	9.2	7.8	8.5	9.5	16.1	13.3	10.9	9.0	8.8
Asia and Pacific	26.4	33.4	34.6	32.9	33.1	21.9	26.7	29.5	26.7	32.6
Europe	53.0	45.3	40.4	37.3	33.8	51.8	48.0	44.4	39.9	36.2
Former Soviet Union	1.2	0.4	0.0	5.3	4.7	0.4	0.3	0.2	9.0	4.6
Latin America	3.8	5.3	8.3	10.3	12.0	5.9	6.6	8.2	9.8	10.8
Oceania	0.4	0.3	0.4	0.5	0.7	0.4	0.4	0.4	0.4	0.5
Total	100	100	100	100	100	100	100	100	100	100

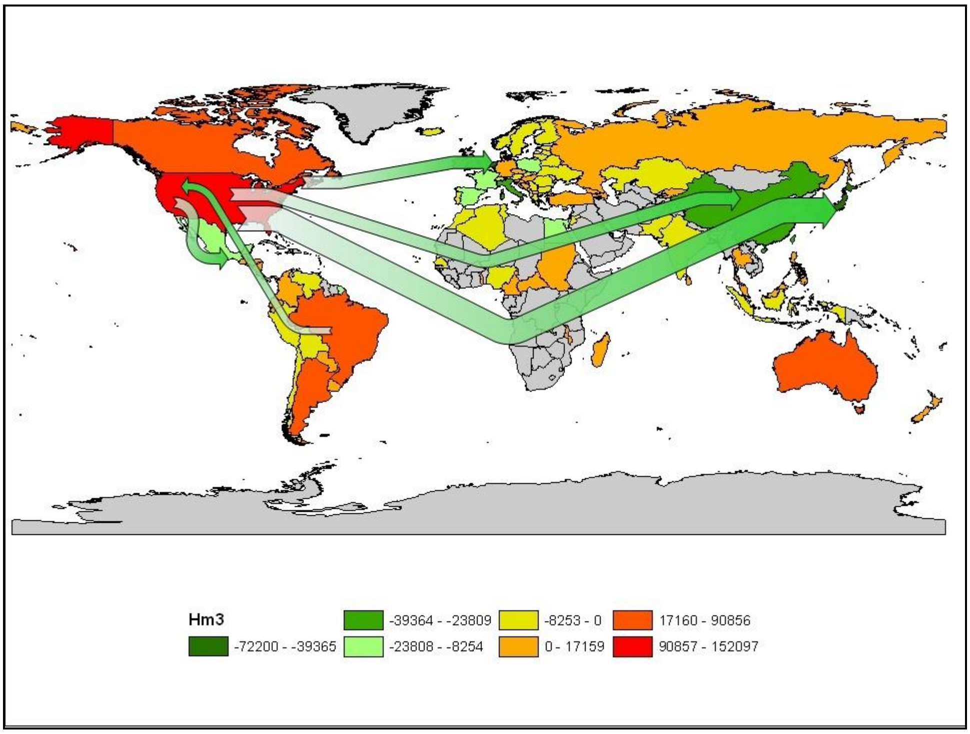
Table 8 in the appendix 1 shows the average virtual water exports, imports and balance in each region during every period. North America and Oceania were net exporters of water in virtual form and tended to reinforce its character throughout the period of analysis. Our findings also show that Europe together with Asia and Pacific were net importers of blue and green water from 1965 to 2010. Both regions consolidated its net importer position particularly from the nineties. The case of Latin America is somehow different; although it was a net exporter of blue water until 1989 and then reverses turning into a slight net importer, it stands out as the most remarkable net exporter of green water particularly from 2000. Certainly the growing agricultural exports from South America to Asia, especially China, explain this turnaround. In this case, green water was mainly embodied in rainfed fodder and other feed stuff crops. Eventually, Africa appears as a net exporter of water until 1980 but becomes a net importer from this moment.

Figure2: Country net exports of green water and top five net flows in the world, 1965



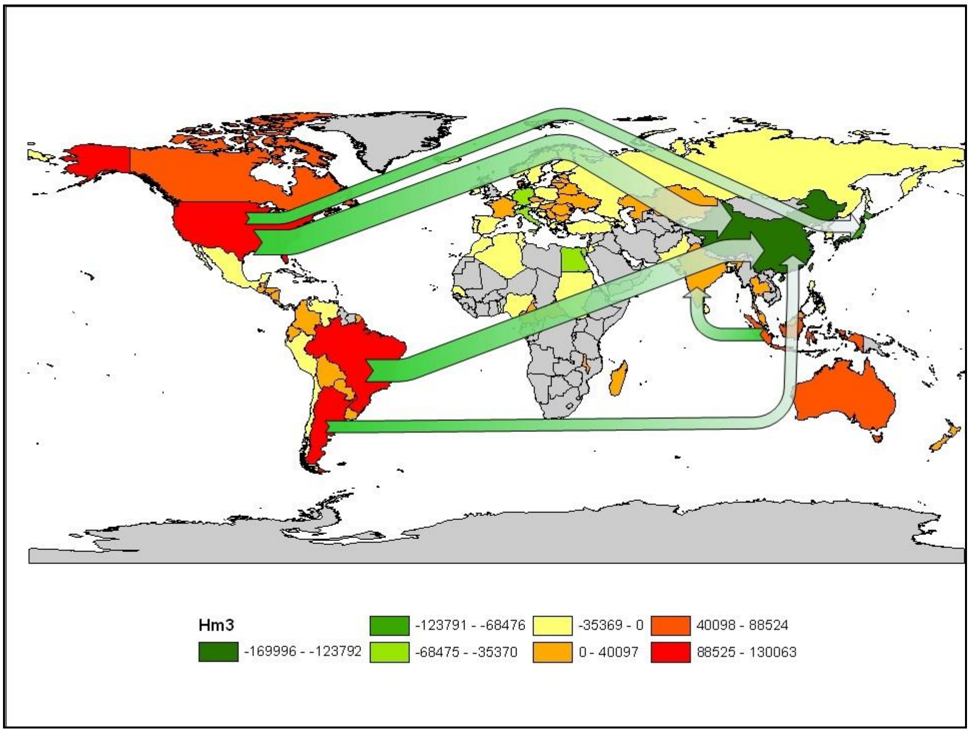
At the country level, it is possible to study not only the countries with the highest flows in the world, but also the origin and destination of these flows. Therefore, Figures 2, 3 and4 display the largest net importers and exporters of green water in the world and the five most important net exchanges of agricultural and food products for 1965, 1980 and 2010. Figure 2 shows that Latin American countries such as Brazil and Argentina exported most green water in 1965. Argentina mainly exported wheat and maize to European states such as Netherlands and Italy. Brazil transferred green water embodied in coffee mainly to USA. Developed countries that have been traditionally exporters of primary products as USA, Canada or Australia can also be highlighted as notable net exporters of green water. USA exported large volumes of green water to Netherlands and mainly to Japan, the highest net importer of green water in the period, showing the most important flow. In this case, green water was embodied mainly in cereals like wheat and soya beans. Most green water from Canada or Australia was embodied in wheat.

Figure 3: Country net exports of green water and top five net flows in the world, 1980



Despite the most remarkable countries in terms of net virtual water flows remained stable in 1980, there were notable changes regarding their contribution to gross virtual water exports and imports. USA virtual exports of green water went from 23% over total green virtual water exports in 1965 to 35% in 1980. On the contrary, Argentinean exports of green water were 12% on total green water exports in 1965 and 5% in 1980. Italy, Netherlands and Japan imported most green water in the world. Furthermore, China notably increased its weight on gross green virtual water imports, from 2% in 1965 to more than 6% in 1980. As the map shows, green water was notably exchanged between USA and Japan, China, The Netherlands, Mexico and Brazil. USA exported green water chiefly embodied in cereals and soya beans, but imported green water from Brazil through coffee.

Figure4: Country net exports of green water and top five net flows in the world, 2010



The picture was somehow different in 2010 (Figure 4). The American continent (chiefly Brazil, Argentina, USA or Canada) kept on being the largest provider of green water in the world. Besides, Italy, Japan and The Netherlands were the main destinations of virtual water flows. Nevertheless, China, with 14% of gross green virtual water imports in the world, is the largest net importer of green water today. Three of the five most important flows in the world went from USA (soya beans), Brazil (wheat) and Argentina (raw cotton) to the Asiatic Dragon. Moreover, the exchange of water mostly from USA to Japan is still noteworthy nowadays (maize).

As for blue water (Figures 5, 6, and 7 for 1965, 1980 and 2010 respectively), USA appears as the highest net exporter in 1965 followed by Mexico or some countries in the north of Africa like Algeria, Egypt or Sudan. On the contrary, Japan or France imported most blue water. As happened in the case of green water, the largest blue virtual water flow went from USA to Japan. Cereals or cotton exchanges were behind these flows. Important blue water displacements also took place as a result of exchanges of wine from Algeria to France, of cotton from Mexico to USA or Japan or of cereals from USA to Netherlands.

Figure5: Country net exports of blue water and top five net flows in the world, 1965

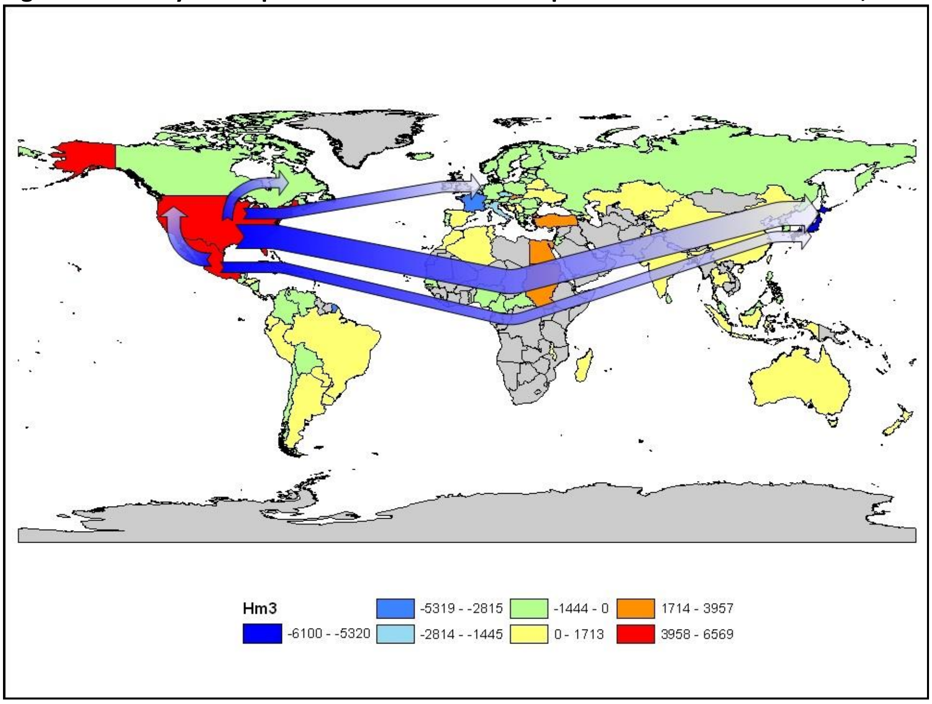
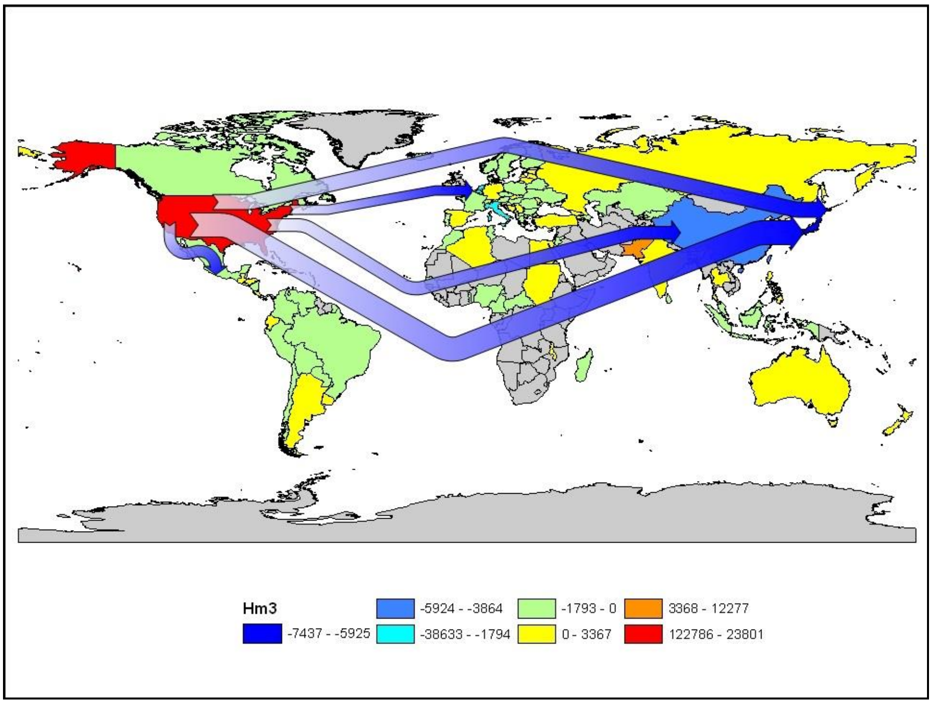


Figure 6: Country net exports of blue water and top five net flows in the world, 1980

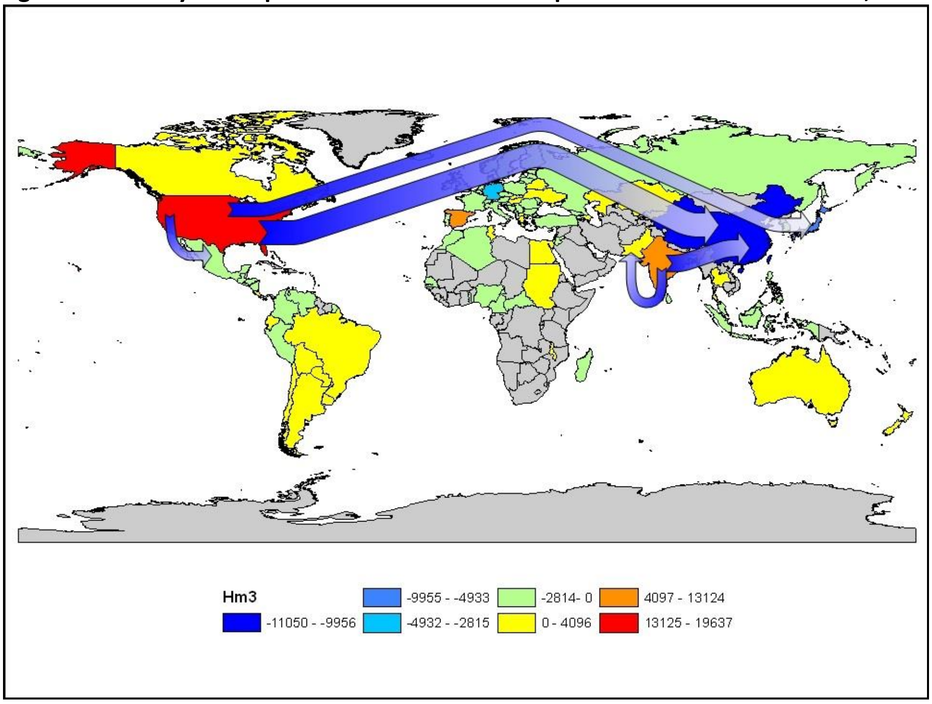


In 1980 USA blue virtual water exports were 46% over global blue exports, whereas USA blue virtual water imports only represented 4% on total imports of blue water. Thus, this country kept on being the main net exporter of blue water in the world, increasing the difference between its volume of blue water exported and imported. Pakistan, Sudan and Spain were also remarkable in terms of blue virtual water exports.

On the contrary, Japan imported large volumes of water. From 1980 China stands out as a significant importer of blue water, followed by other countries like Korea, Italy or The Netherlands. USA was the main origin of blue water virtually exchanged through international trade. The former consumed its own blue water resources to provide cereals, cotton and soya beans to Japan, Korea, Mexico, China or The Netherlands among others.

In 2010 USA was still the largest blue virtual water exporter in the world, followed by India, Spain, Australia or Argentina. Quite the opposite, blue water was imported by China, that became the largest importer of blue water in the world representing more than 14% of blue water imports. Japan, Germany, Korea and United Kingdom were also remarkable net importers of blue water. While USA blue water resources mainly went to China (soya beans), Japan (maize) and Mexico (cereals), Indian blue water was traded in a great amount with China embodied in cotton and also with Pakistan embodied in sugar.

Figure 7: Country net exports of blue water and top five net flows in the world, 2010



The former maps clearly show the variations taken place in terms of the exchanges of virtual water. However to quantify the level of structural change we utilize the Le

Masne (1988) index, which allows to obtain the similarity of virtual water trade flows for each country among different periods and ranges between 0 and 100. The closer the index is to 100, the lower the differences between the two periods are and therefore the higher the similarity is. Table 2 shows the results of the Le Masne index for green and blue water for 1965-2010. The highest values are highlighted in bold, whereas the smallest ones are underlined.

Table 2: Similarity index of virtual water trade flows, 1965-2010

Country	Green water	Blue water	Country	Green water	Blue water
Albania	<u>2.4</u>	21.9	Rep. of Korea	37.9	53.6
Algeria	43.3	27.3	Madagascar	28.3	<u>8.4</u>
Argentina	24.3	23.3	Malawi	25.5	61.8
Australia	43.7	57.7	Malaysia	18.1	48.9
Austria	38.1	41.8	Malta	33.8	27.1
Barbados	40.8	49.4	Mexico	**78.1**	**85.0**
Belgium-Lux.	58.1	46.7	Morocco	47.7	45.4
Bolivia	31.8	27.2	Netherlands	44.1	41.7
Brazil	54.8	41.7	New Zealand	40.0	42.7
Bulgaria	29.0	47.5	Nicaragua	61.5	**80.7**
Cameroon	30.7	14.2	Nigeria	59.4	38.1
Canada	**81.2**	**86.0**	Norway	53.4	46.1
Cent.African Rep.	25.8	19.2	Pakistan	22.9	<u>4.1</u>
Sri Lanka	32.3	38.1	Paraguay	45.6	47.0
Chile	49.0	37.9	Peru	63.7	61.9
China	25.4	13.8	Philippines	56.0	51.9
Colombia	47.5	69.2	Poland	15.7	20.7
Costa Rica	**65.2**	57.5	Portugal	56.3	17.5
Czechoslovakia	<u>8.7</u>	13.5	Romania	25.4	29.4
Denmark	30.3	31.2	Senegal	50.1	44.7
Ecuador	36.9	57.6	Singapore	55.4	58.2
El Salvador	63.5	66.7	Spain	50.7	47.2
Finland	54.1	41.1	Sudan	35.8	67.5
France	41.0	29.5	Sweden	45.6	44.0
Germany	28.3	12.9	Switzerland	41.3	34.8
Greece	44.3	41.5	Thailand	44.7	49.9
Guatemala	**65.8**	**77.3**	Togo	16.5	16.4
Honduras	62.4	61.0	Trinidad Tobago	62.7	**71.5**
Hungary	<u>10.8</u>	22.6	Tunisia	30.1	30.9
Iceland	17.6	46.1	Turkey	29.3	53.6
India	<u>10.4</u>	<u>8.8</u>	Former USSR	<u>3.6</u>	<u>10.0</u>
Indonesia	41.9	48.0	Egypt	53.4	50.4
Ireland	39.7	47.8	United Kingdom	42.3	53.9
Israel	29.4	40.4	USA	54.3	64.2
Italy	54.5	41.5	Uruguay	52.9	30.3
Japan	**76.4**	65.5	Venezuela	32.6	61.4
Jordan	19.5	33.1	Former Yugoslavia	20.7	<u>10.7</u>

Looking at table 2, a remarkable structural change in terms of commercial partners of countries took place between 1965 and 2010. Only some areas like Guatemala, Nicaragua, Mexico and Canada display a similarity index higher than 75 for blue water. As for blue water, Japan, Mexico and Canada depict the largest index. Quite the opposite, India, the Former Soviet Union or Hungary have notably changed their commercial partners concerning virtual water, showing low values of the Le Masne Index.

As it can be observed, China one of the largest importers of water in the world, has a similarity index of 25 and 14 for green and blue water respectively, indicating a clear reorientation of its imports. In 1965 China imported more than 80% of blue water from Pakistan, Egypt and Sudan. This picture had notably changed by 2010, when 43% of blue water came from United States and 25% from India. Likewise, India notably changed its trade patterns throughout the years 1965-2010, with a similarity index around 8 for blue water. If in 1965 95% of blue water resources consumed in India had its origin in Pakistan, today India imports more than 50% from USA and Egypt and only 5% from Pakistan. Finally if we look at USA, outstanding as exporter of virtual water, its similarity index is 54 and 64 for green and blue water respectively, indicating a smoothest structural change. Most blue water was imported from Mexico in both years, being higher in 2010. Furthermore, became a notable provider of blue water in 2010, accounting for 18% of total imports in the United States.

Tables 3, 4 and 5 display several water indicators (gross virtual imports and exports, net virtual water imports, scarcity, self-sufficiency and dependency indexes) at the country level for 1965, 1980 and for 2000. The scarcity index is obtained as the ratio between water availability and water withdrawal. The self-sufficiency index is the ratio between water withdrawal and the sum of net virtual water imports and water withdrawal. It will be equal to 100 if the country is a net exporter of water resources. Finally the dependency index is calculated by dividing net virtual water imports with the sum of net virtual water imports and water withdrawal. This index equals zero if the country is a net exporter of water. Besides, the sum of the self-sufficiency and dependency index equals 100.

United States, Brazil, Canada, India, Colombia and China display the largest water availability in the world. But in per capita terms, countries abundant in water but not very densely populated show the largest water availability per person, as it is the case of Canada, New Zeeland and Latin American areas as Paraguay, Bolivia, Peru and Venezuela. The countries with the highest figures of population in the world like China, USA, India, Indonesia, Pakistan or Japan withdraw large volumes of their domestic resources. From 1965 to 2000 water withdrawal tended to increase in most states with the exception of USA, Malaysia, Bulgaria, Romania, Denmark, Finland, Sweden, Poland, Spain or The Netherlands. Most of these areas are developed nations where the extraction of water resources could have achieved a peak. As stated in Duarte et al. (2013) technical, managerial, economic or even environmental incentives could lie behind the decline in water withdrawal. Besides, the large population increase taken place in many areas of the world during these years made per capita water withdrawal to decrease in the majority of the counties. Only in New Zeeland, Hungary, Bolivia, Uruguay, Greece, United Kingdom and Nigeria water use per person kept increasing. Water extracted has been used to meet domestic demands but a large volume of water resources has been also been utilized to produce goods that have been exchanged through international trade. That way, as we saw in figure 1, virtual water trade flows considerably grew from 1965 to 2010 all over the world. Gross virtual water exports increased in every country except for some African regions. During these years USA, Argentina, Brazil, Australia, Indonesia and Canada depicted the highest figures. On the contrary, Japan, Italy, The Netherlands, United Kingdom and France stand out as the main destination of virtual water in 1965. From 1980, Mexico and China, together with the former countries were among the most relevant water importers in the world. Between 1965 and 2000, gross virtual water imports increased in all countries with the exception of United Kingdom and some Nordic nations. On the one hand, Japan, United Kingdom, Italy, The Netherlands and France were significant net importers of water in 1965. However, in 2000 China was among the most significant water importers in the world. The former countries and others as Korea and Mexico were also net importers of water. On the other hand, USA, Argentina, Brazil, Canada and Australia were the top-five net exporters of water from 1965 to 2010. On the whole, the net importer or net export character remained stable during these years. Only Bolivia and France went from being net importers of water in 1965 to net exporters in 2000. Quite the opposite, Philippines, Turkey and Mexico were net virtual water exporters in 1965 and became net importers by 2000.

According to the scarcity index, during these years scarcity grew in most countries in the world, showing the most concerning values for Egypt, Israel, Jordan, Pakistan, Tunisia and Sudan. Some of these countries are important net exporters of water in spite of being affected by a notable lack of water. In general, it seems quite clear that the patterns of self-sufficiency and dependency remained constant on time. This is the case for most countries but for Malaysia, Bolivia, France, Ireland and Denmark that during the sixties used to be very dependent on water coming from abroad and now appear as net exporters of water resources and auto-sufficient. Currently, countries such as The Netherlands, Korea, Algeria, Israel or Jordan have a high dependency index as a result of agricultural and food products imports. Besides, it is possible to find an increase in the auto-sufficiency of Austria, Greece, Norway, Poland and the United Kingdom. Finally, Senegal, Jordan, Peru, Venezuela, Israel, Nigeria, Morocco, Algeria, Mexico and Japan notably increased their dependency on foreign water resources.

Table 3: Water availability, withdrawal, Gross VWM, Gross VWX and Net VWM in 1965

Country	Population (000 hab.)	Water avail. (km^3)	Water with. (km^3)	Gross VWM (km^3)	Gross VWX (km^3)	Net VWM (km^3)	Scarcity index	Self-suff.index (%)	Dep. index (%)
USA	194,303	3,069	517.7	53.9	92.5	-38.6	6	100	0
Argentina	22,283	814	27.6	1.5	44.1	-42.5	29	100	0
Brazil	83,093	8,233	35.0	7.2	34.4	-27.2	235	100	0
Canada	20,071	2,902	42.2	11.4	23.1	-11.6	69	100	0
Australia	11,439	492	n.a.	1.0	19.4	-18.4	n.a.	100	0
Indonesia	105,913	2,019	74.3	0.6	4.5	-3.8	27	100	0
Thailand	32,062	439	n.a.	0.6	10.3	-9.7	n.a.	100	0
Malaysia	9,648	580	10.1	3.8	1.2	2.6	57	79	21
New Zealand	2,640	327	1.2	1.0	7.9	-6.8	273	100	0
Paraguay	2,170	336	0.4	0.2	0.8	-0.6	781	100	0
Hungary	10,153	104	4.8	2.2	3.0	-0.8	22	100	0
Colombia	18,646	2,132	n.a.	1.0	8.5	-7.6	n.a.	100	0
Guatemala	4,746	111	n.a.	0.4	2.5	-2.1	n.a.	100	0
Cameroon	6,104	286	0.4	0.1	1.4	-1.3	714	100	0
Bolivia	3,853	623	1.2	0.4	0.1	0.3	502	80	20
Nicaragua	1,750	197	n.a.	0.2	2.7	-2.5	n.a.	100	0
India	485,000	1,911	438.3	1.3	12.6	-11.3	4	100	0
Sudan	12,086	53	14.1	0.5	4.3	-3.7	4	100	0
France	49,802	211	31.0	24.9	7.7	17.2	7	64	36
Uruguay	2,693	139	1	0	2	-1.8	214	100	0
Ireland	2,876	52	0.8	1.4	0.9	0.5	66	59	41
Ecuador	5,118	424	n.a.	0.2	1.8	-1.5	n.a.	100	0
Tunisia	4,566	5	1.9	1.0	2.7	-1.7	2	100	0
Madagascar	6,070	337	16.3	0.3	2.4	-2.1	21	100	0
Malawi	3,914	17	n.a.	0.0	0.5	-0.5	n.a.	100	0
Bulgaria	8,201	21	14.2	1.0	1.5	-0.6	2	100	0
Romania	19,027	212	18.8	0.4	2.0	-1.5	11	100	0
El Salvador	3,018	25	0.7	0.7	1.0	-0.2	35	100	0
Denmark	4,758	6	1.1	5.2	5.0	0.2	5	85	15
Central African Rep.	1,628	144	n.a.	0.0	2.4	-2.4	n.a.	100	0
Austria	7,271	78	3.3	1.6	0.6	1.0	23	76	24
Albania	1,884	42	1.2	0.3	0.0	0.3	35	82	18
Finland	4,564	110	3.7	2.2	0.3	1.9	30	67	33
Senegal	3,744	39	1.4	0.9	2.3	-1.4	29	100	0
Greece	8,550	74	5.0	3.1	0.9	2.3	15	69	31
Norway	3,723	382	2.0	3.0	0.1	2.9	191	41	59
Sweden	7,734	174	4.1	4.8	0.8	4.0	42	51	49
Poland	31,262	62	15.1	7.2	2.9	4.2	4	78	22
Philippines	33,268	479	n.a.	3.2	8.2	-5.1	n.a.	100	0
Peru	11,467	1,913	19.0	3.0	2.1	0.9	101	95	5
Jordan	1,061	1	0.5	0.5	0.0	0.5	2	53	47
Pakistan	57,495	247	155.6	0.0	0.0	0.0	2	100	0
Chile	8,510	922	20.3	2.3	0.2	2.1	45	91	9
Venezuela	9,068	1,233	4.1	2.4	1.4	1.0	301	80	20
Israel	2,578	2	1.7	3.1	0.3	2.8	1	38	62
Portugal	9,129	69	n.a.	1.7	0.3	1.4	n.a.	n.a.	n.a.
Nigeria	48,064	286	3.6	0.4	0.2	0.2	79	94	6
Morocco	14,066	29	10.1	1.9	1.9	-0.1	3	100	0
Turkey	31,951	212	31.6	1.2	3.9	-2.7	7	100	0
Spain	32,085	112	39.9	8.1	3.0	5.1	3	89	11
Algeria	11,963	12	3.0	1.2	2.5	-1.3	4	100	0
United Kingdom	54,350	147	13.5	47.6	1.3	46.2	11	23	77
Egypt	30,265	57	48.2	7.2	2.8	4.4	1	92	8
China	715,185	2,840	443.7	9.2	8.2	1.0	6	100	0
Rep. of Korea	28,705	70	n.a.	2.8	0.1	2.7	n.a.	n.a.	n.a.
Netherlands	12,292	91	9.2	31.1	7.9	23.2	10	28	72
Mexico	45,142	457	56	1	14	-13.4	8	100	0
Italy	51,987	191	41.6	37.9	2.2	35.7	5	54	46
Japan	98,883	430	88	46	0	46.3	5	66	34

Table 4: Water availability, withdrawal, Gross VWM, Gross VWX and Net VWM in 1980

Country	Population	Water avail. (km^3)	Water with.(km^3)	Gross VWM (km^3)	Gross VWX (km^3)	Net VWM (km^3)	Scarcity index	Self-suff.index	Dep. index
USA	227,726	3,069	517.7	55.1	230.7	-175.6	6	100	0
Argentina	28,370	814	27.6	1.8	28.4	-26.6	29	100	0
Brazil	123,020	8,233	35.0	16.8	58.5	-41.7	235	100	0
Canada	24,593	2,902	42.2	10.0	33.6	-23.6	69	100	0
Australia	14,616	492	n.a.	1.5	39.8	-38.3	n.a.	100	0
Indonesia	147,490	2,019	74.3	11.3	8.9	2.4	27	97	3
Thailand	47,026	439	n.a.	2.5	16.1	-13.5	n.a.	100	0
Malaysia	13,764	580	10.1	5.6	10.8	-5.2	57	100	0
New Zealand	3,170	327	1.2	0.6	9.1	-8.5	273	100	0
Paraguay	3,196	336	0.4	0.3	1.7	-1.4	781	100	0
Hungary	10,711	104	4.8	1.9	2.2	-0.3	22	100	0
Colombia	26,631	2,132	n.a.	2.2	12.8	-10.5	n.a.	100	0
Guatemala	6,650	111	n.a.	0.6	3.5	-2.9	n.a.	100	0
Cameroon	8,762	286	0.4	1.5	3.2	-1.7	714	100	0
Bolivia	5,441	623	1.2	1.1	0.6	0.5	502	73	27
Nicaragua	2,805	197	n.a.	0.6	1.8	-1.2	n.a.	100	0
India	679,000	1,911	438.3	7.4	7.1	0.3	4	100	0
Sudan	19,064	53	14.1	0.8	4.4	-3.6	4	100	0
France	55,110	211	31.0	34.6	19.6	15.0	7	67	33
Uruguay	2,930	139	1	0	2	-1.9	214	100	0
Ireland	3,401	52	0.8	1.5	4.2	-2.6	66	100	0
Ecuador	7,920	424	n.a.	1.2	3.0	-1.8	n.a.	100	0
Tunisia	6,443	5	1.9	2.6	1.7	0.9	2	68	32
Madagascar	8,691	337	16.3	0.4	2.4	-2.1	21	100	0
Malawi	6,259	17	n.a.	0.0	0.8	-0.8	n.a.	100	0
Bulgaria	8,844	21	14.2	1.0	0.8	0.2	2	99	1
Romania	22,130	212	18.8	6.0	1.0	5.0	11	79	21
El Salvador	4,566	25	0.7	0.6	0.8	-0.2	35	100	0
Denmark	5,123	6	1.1	5.4	4.3	1.1	5	49	51
Austria	2,349	144	n.a.	0.0	3.8	-3.8	n.a.	100	0
Albania	7,549	78	3.3	1.8	0.7	1.1	23	75	25
Finland	2,671	42	1.2	0.1	0.1	0.0	35	97	3
Senegal	4,780	110	3.7	2.2	0.3	1.9	30	66	34
Greece	5,787	39	1.4	2.1	1.5	0.7	29	67	33
Norway	9,643	74	5.0	5.8	1.2	4.6	15	52	48
Sweden	4,086	382	2.0	3.7	0.3	3.4	191	37	63
Poland	8,310	174	4.1	4.3	0.6	3.7	42	52	48
Peru	35,578	62	15.1	14.3	2.3	12.0	4	56	44
Jordan	50,940	479	n.a.	4.0	12.4	-8.4	n.a.	100	0
Pakistan	17,295	1,913	19.0	4.2	1.0	3.2	101	85	15
Chile	2,163	1	0.5	1.5	0.0	1.5	2	27	73
Venezuela	85,219	247	155.6	3.2	6.4	-3.3	2	100	0
Israel	11,094	922	20.3	4.9	0.5	4.4	45	82	18
Portugal	14,768	1,233	4.1	5.8	0.2	5.6	301	42	58
Nigeria	3,737	2	1.7	3.6	0.7	2.9	1	37	63
Morocco	9,778	69	n.a.	7.9	0.6	7.3	n.a.	n.a.	n.a.
Turkey	74,821	286	3.6	5.1	0.1	5.1	79	42	58
Spain	19,487	29	10.1	4.3	1.5	2.8	3	78	22
Algeria	45,048	212	31.6	1.1	3.1	-2.1	7	100	0
United Kingdom	37,488	112	39.9	18.8	5.7	13.1	3	75	25
Egypt	18,806	12	3.0	7.9	1.5	6.3	4	32	68
China	56,314	147	13.5	24.8	7.0	17.8	11	43	57
Rep. of Korea	42,634	57	48.2	16.5	1.6	14.9	1	76	24
Netherlands	981,235	2,840	443.7	42.6	5.7	36.9	6	92	8
Mexico	38,124	70	n.a.	16.2	0.3	15.9	n.a.	n.a.	n.a.
Italy	14,144	91	9.2	58.0	14.8	43.2	10	18	82
Japan	68,347	457	56	21	6	14.4	8	80	20

Table 5: Water availability, withdrawal, Gross VWM, Gross VWX and Net VWM in 2000

Country	Population	Water avail. (km^3)	Water with.(km^3)	Gross VWM (km^3)	Gross VWX (km^3)	Net VWM (km^3)	Scarcity index	Self-suff.index	Dep. index
USA	282,158	3,069	473.4	77.2	187.6	-110.4	6	100	0
Argentina	37,336	814.0	32.6	10.6	89.6	-79.0	25	100	0
Brazil	176,320	8233.0	59.3	27.7	77.0	-49.3	139	100	0
Canada	31,100	2902.0	n.a.	16.4	62.2	-45.8	n.a.	100	0
Australia	19,053	492.0	22.6	2.8	36.3	-33.5	22	100	0
Indonesia	205,132	2019.0	113.3	19.1	37.1	-18.0	18	100	0
Thailand	61,863	438.6	57.3	10.4	25.6	-15.2	8	100	0
Malaysia	21,804	580.0	9.3	14.3	29.4	-15.1	62	100	0
New Zealand	3,802	327.0	4.8	1.1	15.3	-14.1	69	100	0
Paraguay	5,592	336.0	0.5	0.7	8.7	-8.0	686	100	0
Hungary	10,137	104.0	5.8	1.9	7.2	-5.3	18	100	0
Colombia	39,817	2132.0	12.7	7.5	11.8	-4.2	169	100	0
Guatemala	11,085	111.3	2.8	2.4	5.9	-3.5	40	100	0
Cameroon	15,343	285.5	1.0	0.4	3.9	-3.4	295	100	0
Bolivia	8,195	622.5	2.6	1.4	4.6	-3.2	235	100	0
Nicaragua	4,935	196.6	1.4	0.7	3.4	-2.8	142	100	0
India	1,004,124	1911.0	610.4	26.3	29.0	-2.7	3	100	0
Sudan	34,194	52.8	27.2	1.1	2.9	-1.8	2	100	0
France	61,137	211.0	32.4	31.9	33.5	-1.6	7	100	0
Uruguay	3,328	139	4	3	4.9	-1.6	38	100	0
Ireland	3,792	52.0	n.a.	2.5	4.1	-1.5	n.a.	100	0
Ecuador	12,446	424.4	9.4	1.9	3.1	-1.2	45	100	0
Tunisia	9,568	4.6	2.9	4.8	5.8	-1.0	2	100	0
Madagascar	15,742	337.0	16.5	0.5	1.4	-1.0	20	100	0
Malawi	11,560	17.3	1.3	0.0	0.8	-0.8	13	100	0
Bulgaria	7,818	21.3	5.7	1.4	2.1	-0.8	4	100	0
Romania	22,452	211.9	9.2	2.8	3.2	-0.4	23	100	0
El Salvador	6,126	25.2	1.4	2.0	2.2	-0.2	18	100	0
Denmark	5,337	6.0	0.7	7.0	7.1	-0.1	9	100	0
Austria	3,940	144.4	0.1	0.0	0.1	0.0	2,181	100	0
Albania	8,113	77.7	3.7	3.7	3.3	0.4	21	89	11
Finland	3,474	41.7	1.8	0.6	0.0	0.6	23	75	25
Senegal	5,169	110.0	2.3	2.1	0.8	1.3	48	64	36
Greece	10,678	38.8	2.2	2.5	1.1	1.4	17	62	38
Norway	10,559	74.3	9.3	6.7	4.9	1.9	8	83	17
Sweden	4,492	382.0	2.4	2.5	0.3	2.3	160	51	49
Poland	8,872	174.0	2.7	3.9	1.1	2.8	65	49	51
Peru	38,654	61.6	12.9	6.5	3.6	2.9	5	82	18
Jordan	81,222	479.0	78.9	12.6	9.3	3.3	6	96	4
Pakistan	26,087	1913.0	19.3	5.4	2.0	3.5	99	85	15
Chile	4,999	0.9	0.9	4.1	0.0	4.0	1	19	81
Venezuela	146,405	246.8	172.6	9.8	4.9	4.8	1	97	3
Israel	15,156	922.0	24.7	6.2	1.3	4.9	37	83	17
Portugal	23,493	1233.0	9.1	6.6	1.0	5.6	136	62	38
Nigeria	6,115	1.8	1.8	6.8	0.7	6.1	1	23	77
Morocco	10,336	68.7	8.5	9.7	3.1	6.6	8	56	44
Turkey	123,179	286.2	10.3	6.7	0.0	6.7	28	60	40
Spain	30,184	29.0	12.6	8.6	1.4	7.1	2	64	36
Algeria	67,329	211.6	42.0	14.3	6.9	7.5	5	85	15
United Kingdom	40,016	111.5	36.0	29.0	20.7	8.3	3	81	19
Egypt	30,429	11.7	5.7	10.1	0.1	10.0	2	36	64
China	59,522	147.0	15.6	24.8	9.2	15.6	9	50	50
Rep. of Korea	70,512	57.3	55.3	24.8	9.2	15.6	1	78	22
Netherlands	1,262,645	2840.0	554.1	46.7	22.4	24.4	5	96	4
Mexico	46,839	69.7	25.5	31.5	1.3	30.2	3	46	54
Italy	15,908	91.0	8.9	60.6	26.7	33.9	10	21	79
Japan	99,927	457.2	73	50	14.7	34.8	6	68	32

In addition to the great increase in the volume of virtual water traded, variations in the agricultural and food products exchanged also took place (Table 6). An important group of goods like cereals and cereals preparations that entailed more than 32% of green virtual water trade during the seventies, has now experienced a notable loss of weight, representing about 22% in the case of green water and 27% for blue water. Not manufactured textile fibers also went through a reduction of their shares on time, particularly in the case of blue water, turning from 33% over the sixties to approximately 14% today, mainly due to the substitution of natural fibers for synthetic fibers. The same happened with the group coffee, tea and spices since a decline of their shares for green water was observed. Nevertheless other crops and products made up for these reductions. This was the case of fruits and vegetables that considerably increased their participation mainly in blue water, accounting for 15% of total exchanges of blue water nowadays. Dairy products and eggs (4% of blue water) as well as meat and meat preparations (6.9% of blue water currently), growing products in current diets, also experienced a rise of weight chiefly if we look at blue water. Regarding green water, the meat group has remained quite stable at 11%. Fixed vegetable oils and fats, also basic for human diets, more than doubled their participation concerning commercial exchanges of green water. Eventually, crops commonly used as animal feed such as feed stuff or oil seeds, oil nuts and kernels show growing and outstanding percentages for green water, reaching 8% and 15.4% respectively nowadays. We have seen that the increasing level of development in some world regions lead an important change in world diets, with a growing weight of high value added commodities such as fruits, vegetables, dairy products, vegetal oils or meat. Besides, the rise of meat and other goods derived from livestock resulted in an upward trend of animal feed crops like feed stuff or oil seeds. Thus, changes in the product composition of virtual water trade tend to be similar when the composition of world trade in agri-food products is analyzed in monetary value. In this case, processed and high value added commodities have also increased their share, whereas basic products have lost weight. Processed products of higher value have benefited from free trade and from the new intra-industry trade patterns (Serrano and Pinilla, 2013).

Table 6: Average contribution of products to virtual water exports and imports (%)

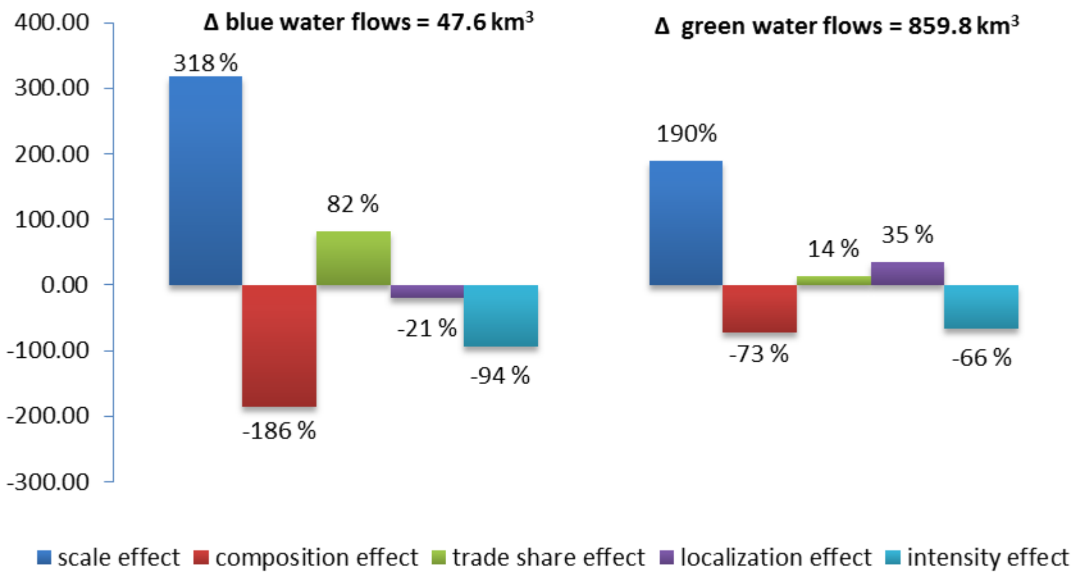
	Blue water					Green water				
Sitc rev.1 product classification	**1965-1969**	**1970-1979**	**1980-1989**	**1990-1999**	**2000-2010**	**1965-1969**	**1970-1979**	**1980-1989**	**1990-1999**	**2000-2010**
00 Live animals	1.1	0.9	0.8	0.6	0.5	3.6	2.6	2.2	1.3	1.0
01 Meat and meat prep.	5.3	5.6	5.5	5.9	6.9	13.2	11.3	11.6	10.0	11.1
02 Dairy products and eggs	2.7	3.2	3.4	3.7	4.1	3.2	3.6	4.0	3.9	4.0
04 Cereals and cereal prep.	26.2	31.5	29.7	28.8	26.9	34.5	33.8	27.0	26.5	22.1
05 Fruit and vegetables	6.9	7.9	9.2	12.9	15.0	2.6	3.5	4.2	4.9	5.6
06 Sugar, sugar prep., honey	5.2	5.9	5.2	6.5	5.5	2.1	2.3	2.0	2.2	2.2
07 Coffee, tea, spices	2.3	2.1	2.0	2.0	1.7	17.3	14.8	13.2	14.0	7.9
08 Feed. Stuff Unmilled cereals	3.5	3.9	4.8	5.6	5.6	3.1	3.9	6.6	8.3	8.0
09 Miscellaneous food prep.	0.0	0.0	0.1	0.3	0.4	0.0	0.0	0.0	0.1	0.1
11 Beverages	3.2	1.5	0.9	1.5	1.5	0.5	0.7	0.8	0.9	0.9
12 Tobacco	0.4	0.4	0.3	0.4	0.4	0.6	0.4	0.3	0.3	0.3
21 Hides, skins and fur skins	0.4	0.4	0.8	1.6	0.7	0.9	1.0	1.8	1.7	1.2
22 Oil seeds, oil nuts	6.3	7.6	8.4	8.8	10.0	7.6	10.1	12.3	11.5	15.8
26 Textile fibres, not manuf.	32.7	22.7	20.6	15.1	13.9	5.5	4.1	3.1	2.3	2.2
29 Crude anim. and veg. mat.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42 Fixed veg. oils and fats	3.5	6.0	7.6	5.9	5.4	4.8	7.2	10.1	10.7	15.4
59 Chemical materials	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.2	0.2	0.3
61 Leather, lthr. Manufs.	0.1	0.2	0.4	0.6	1.3	0.3	0.5	0.8	1.2	1.7
Total	100	100	100	100	100	100	100	100	100	100

3.2. Factors driving global virtual water flows in the long term

We have seen that exchanges of water in virtual form experienced a great increase from 1965 to 2010. This process can be associated with the growth in the volume of trade, with changes in the main products traded, with changes in the origin of embodied water, with variations in the most important exporters and importers of water as well as with yield improvements. In the following we are going to apply a decomposition analysis to study the contribution that each of the previous factors could have had in the explanation of the growing trend followed by virtual water flows.

Figure 6 shows the impact that each of the factors previously defined had in the increase in blue and green water from 1965 to 2010 in the world. Scale effect, that is, the great growth of commercial exchanges during these years was responsible for most of the increase in blue and green water consumption. From 1965 to 2010 some Latin American states as Mexico or African areas like Egypt, Algeria or Sudan reduced their share in trade of embodied water resources. However Asiatic regions such as China, India or Indonesia, American countries like Canada as well as Spain hugely increased their weights. These changes in the share of countries in virtual water trade also involved a boost of water consumption. Nevertheless compositional changes (variations in traded products) together with yield improvements at the global level contributed to the slowdown of the growth in water consumption. It seems that without the key role of these two elements water consumption would have increased 1,328 km^3 more. On the one hand, the decreasing shares of cereals such as wheat and maize highly intensive in green water, as well as the reduction of importance of coffee, moderated green water consumption rise at a great extent. On the other hand, it is observed an outstanding loss of weight of raw sugar but particularly of raw cotton, crops that embodied large volumes of blue water and that consequently drove the leveling off of blue virtual water flows. Moreover, the fact that crops and livestock yields improved in most world regions, involved a decrease in the volume of water necessary to produce a ton of product and therefore a deceleration of water consumption.

Figure 8: Factors explaining virtual water flows increase in the world, 1965-2010



As it is observed in Figure 8, localization effect had a negative effect in blue water consumption, but a positive impact in the case of green water. As for blue water, on the whole, products were produced in less water intensive countries and then exported, resulting in a smoother water consumption growth. Mexico and USA were the most significant providers of blue water in the world, what seems to keep constant on time. Despite in 1965 African countries as Egypt and Algeria or Oceania areas such as New Zeeland and Australia also outstand as consumers of their own resources for exports, currently new states like India or Spain appear. On the contrary, the reallocation of the production of green water intensive goods made water consumption to increase. In this regard, green water had its origin mainly in USA and Argentina during all these years. However whereas Brazil, Australia, Colombia or Philippines could be highlighted as important origins of green water in 1965, Canada, Indonesia, Netherlands or India stand out nowadays.

After examining the impact that the different effects exert on virtual water at a global level, we are going to deal with their impact in the seven regions (Table 7) in which we have divided the world. Results at the country level are given in Tables 9 and 10 in the appendix 1. Regarding exports, blue and green virtual water increased in all areas except Africa where slight decreases happened. Scale effect appears as the most important factor driving blue and green water exports growth. However, there are some regional disparities in the case of composition and trade share effects. As for green water, compositional changes partially offset the water consumption increase being its magnitude more relevant in Latin America and North America. In the case of blue water, the former effect had an important contribution to water consumption moderation in Latin America, but triggers water consumption growth in Oceania and in the Former Soviet Union. Changes in the importance of countries in exports, i.e. trade share effect, clearly involves water consumption stabilization in North America, Latin America, Oceania and Africa. However it boosts water consumption in Europe and the Former Soviet Union. For Asia, trade share effect makes blue virtual water exports to level off but entails a slight growth of green water exports. Finally, yield improvements occurred in every world region and avoided larger increases in water consumption. As an example, technological advances prevented consuming approximately 204 km^3 of water in Asia and Europe.

If we turn to the explaining factors of virtual water imports increase at a regional level, again scale effect was the main contributing factor to virtual water imports growth. Compositional changes drove water consumption stabilization, with the exception of green water in Latin America where it showed a small but positive sign. In the third place, changes in the origin of products made embodied blue and green water in imports to moderate in Europe and Latin America. Changes in the share of countries in trade was a driving factor of water consumption slow down in the most developed regions of the sample, North America and Europe. As happened with exports, yield improvements boosted water consumption deceleration all over the world, particularly in Europe and North America. Eventually, whereas variations in the share of countries on international trade made blue water to slow down, trade share effect had the opposite impact for green water, triggering its consumption.

Table 7: Change in virtual water flows and decomposition analysis effects, 1965-2010

	VWE Change (km^3)	**SE** (%)	**CE** (%)	**TE** (%)	**IE** (%)	**VWM Change** (km^3)	**SE** (%)	**CE** (%)	**LE** (%)	**TE** (%)	**IE** (%)
						Blue water					
Africa	-3.1	-631	109	572	51	5.4	122	-26	59	-6	-49
North America	16.7	241	-25	-59	-57	3.4	480	-99	-159	-38	-83
Asia	10.4	274	11	-63	-122	19.1	225	-162	124	-6	-80
Europe	15.4	163	-11	29	-81	8.2	890	-378	-107	-71	-234
Former USSR	3.6	54	13	58	-25	2.6	127	-833	854	0	-48
Latin America	3.7	630	-344	-74	-113	8.4	101	1	51	-14	-40
Oceania	2.2	362	14	-184	-92	0.6	162	-39	28	-6	-45
						Green water					
Africa	-6.2	-889	16	913	60	70.5	120	-50	66	12	-49
North America	144.6	274	-50	-54	-71	35.3	572	-180	-204	19	-107
Asia	184.4	142	-6	9	-45	353.6	127	-84	52	47	-42
Europe	183.5	142	-6	69	-104	235.8	314	-70	-54	34	-123
Former USSR	101.2	62	-17	90	-35	58.4	51	-79	97	59	-27
Latin America	221.4	207	-55	2	-54	100.4	115	-17	35	6	-39
Oceania	30.5	346	-7	-175	-63	5.9	134	-30	18	16	-38

VWE change: change in virtual water exports (km^{3}), VWM change: change in virtual water imports (km^{3}), SE: Scale effect (%), CE: Composition effect (%), LE: localization effect (%), TE: Trade share effect (%), IE: Intensity effect (%)

4. Conclusions

Our study shows that the commercial integration happened between 1965 and 2010 entailed large pressures on water resources at the global level. The strong increase in agri-food trade in this period has been the main driver of the increase in virtual water trade. Changes in the composition of trade as a result of the decline of the exchanges of water intensive crops such as cotton, coffee, maize or rice have alleviated pressures on water. The same has happened with technological improvements that have also contributed to a lower pressure on water resources. It suggests the need to analyze the implications of globalising processes on the environment. The growing integration in international trade of many countries is essential to understand their water consumption.

It's difficult to find a general pattern to explain the situation of each country in terms of dependence on foreign water resources. On the whole, the availability of natural resources as water and land together with the level of economic development can be useful to understand it. Hence, developed countries with a low land/labor ratio usually show a high dependence on foreign water. This would be the case of European countries like United Kingdom, Italy, The Netherlands or Portugal. Some Asian countries as Israel, Japan or Korea would behave the same way. Likewise, developing countries that need to import large volumes of agricultural and food products are also dependent on foreign water in several degrees, as for instance, China, Egypt or Mexico. Quite the opposite, as for countries with high net exports of virtual water, we find different patterns. On the one hand, we find developed countries that are abundant in land and that have been exporters of agricultural products historically. This is the case of USA, Canada, Australia or New Zealand. On the other hand, we find emerging countries abundant in land with a long term specialization in agricultural exports like Argentina, Brazil, Indonesia, Thailand or Malaysia. These patterns have hardly changed throughout this period.

Some industrialized countries, with small relative availability of land tend to externalize the most intensive production systems to emerging regions that stand out for being mostly producers of primary inputs and agricultural goods and also to industrialized countries abundant in land.

Thus, we are facing a concerning situation that tends to consolidate and that is increasingly leading to a separation of consumer and producer responsibilities. In other words, water resources are overexploited and polluted to produce goods that are consumed in distant places different from the place where water was withdrawn. In the light of historical processes, it seems necessary to look for a global and sustainable notion of virtual water in order to address unequal exchanges of water, avoiding the displacements of environmental burdens to water scarce or inefficient areas. In this line, water should be priced accurately, so that each exchanged product reflected both the full environmental and economic cost of its production. On the one hand, consumers would bear the real cost of producing agricultural and food commodities, paying for its water consumption responsibility. On the other hand, producing areas could improve water efficiency or even restore water ecosystems with extra income. To that aim, it is essential to adopt multilateral agreements seeking for a joint management of water resources and to develop useful tools that help to measure accurately the water consumption throughout the whole production, distribution and consumption chains in the world.

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Appendix1

Table 8: Average virtual water exports, imports and balance (km^3)

	1965-1969	1970-1979	1980-1989	1990-1999	2000-2010	1965-1969	1970-1979	1980-1989	1990-1999	2000-2010
	Blue water exports					**Green water exports**				
Africa	5.3	4.5	3.5	3.1	4.8	15.7	15.9	14.5	16.2	13.5
North America	7.2	11.1	13.5	19.6	27.3	67.3	107.3	123.9	194.3	249.4
Asia and Pacific	4.3	4.9	7.7	12.2	19.7	36.1	41.1	63.8	142.8	213.9
Europe	3.8	5.6	8.6	13.9	19.6	40.3	57.9	88.8	153.7	209.7
Former Soviet Union	0.1	0.1	0.1	3.8	3.2	5.7	3.0	1.0	45.3	76.0
Latin America	5.0	4.1	3.4	5.8	10.0	77.3	88.0	106.1	183.2	334.8
Oceania	1.4	1.4	2.3	4.4	5.9	21.2	31.4	35.3	36.7	49.0
Total	27.1	31.6	39.1	62.8	90.5	263.6	344.7	433.5	772.2	1,146.3
	Blue water imports					**Green water imports**				
Africa	0.8	1.9	3.3	3.3	5.9	8.7	15.4	26.7	40.8	74.9
North America	3.5	3.1	3.2	5.3	8.3	45.4	48.3	48.9	70.4	98.6
Asia and Pacific	6.9	10.4	13.5	20.7	30.9	59.3	92.4	127.4	206.9	376.8
Europe	14.4	14.4	15.8	23.3	29.8	133.4	163.9	191.4	302.6	413.1
Former USSR	0.2	0.1	0.0	3.3	4.2	0.9	0.7	1.1	71.0	53.9
Latin America	1.0	1.7	3.3	6.6	10.8	14.9	22.6	36.1	77.4	122.9
Oceania	0.1	0.1	0.1	0.3	0.6	1.0	1.3	2.0	3.1	6.1
Total	27.1	31.6	39.1	62.8	90.5	263.6	344.7	433.5	772.2	1,146.3
	Blue balance					**Green balance**				
Africa	4.5	2.7	0.3	-0.1	-1.0	7.1	0.5	-12.2	-24.6	-61.4
North America	3.6	8.0	10.3	14.3	19.0	21.9	59.1	75.0	123.9	150.8
Asia and Pacific	-2.7	-5.5	-5.8	-8.5	-11.2	-23.2	-51.3	-63.6	-64.2	-163.0
Europe	-10.6	-8.9	-7.1	-9.4	-10.2	-93.2	-106.1	-102.6	-148.9	-203.4
Former USSR	-0.1	0.0	0.1	0.4	-1.0	4.8	2.3	0.0	-25.6	22.1
Latin America	4.0	2.4	0.1	-0.7	-0.8	62.4	65.4	70.0	105.8	211.9
Oceania	1.3	1.3	2.1	4.1	5.2	20.2	30.1	33.4	33.6	43.0
Total	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 9: Change in virtual water exports and decomposition analysis at the country level, 1965-2010

	Green virtual water exports					Blue virtual water exports				
	VWE change (km^3)	**SE** (%)	**CE** (%)	**TE** (%)	**IE** (%)	**VWE change** (km^3)	**SE** (%)	**CE** (%)	**TE** (%)	**IE** (%)
Albania	0.07	115	-90	46	30	0.02	86	-41	29	26
Algeria	-1.21	-289	-20	377	31	-1.44	-267	19	321	27
Argentina	62.74	230	-53	-47	-30	1.81	270	-52	-57	-61
Australia	19.83	391	-17	-194	-81	1.45	402	24	-199	-126
Austria	3.55	90	-21	62	-31	0.11	76	12	45	-33
Barbados	-0.47	-306	2	370	34	0.00	471	517	-874	-14
Belgium-Lux.	12.16	97	-47	79	-29	0.42	83	-26	61	-18
Bolivia	5.16	50	-41	44	47	0.04	55	-42	67	20
Brazil	99.94	173	-52	63	-84	0.71	374	-341	155	-88
Bulgaria	5.01	156	-9	-48	1	0.14	117	1	-33	15
Cameroon	0.14	3982	-307	-3543	-32	0.00	152	80	-126	-5
Canada	58.77	163	-28	6	-41	3.23	76	27	2	-4
Cent. African Rep.	-2.84	-311	0	394	17	0.00	-300	-24	373	50
Sri Lanka	-0.82	-1140	-27	1126	141	0.03	73	113	-70	-15
Chile	1.89	65	-146	192	-10	0.68	95	-410	430	-16
China	5.28	492	-394	201	-199	-0.11	-2693	3190	-1204	807
Colombia	6.22	467	-58	-284	-26	0.06	178	9	-99	12
Costa Rica	5.36	207	-154	45	1	0.18	157	-64	32	-25
Czechoslovakia	5.53	394	705	1452	-2451	0.38	176	1403	558	-2037
Denmark	3.55	450	-26	-244	-80	0.17	423	-26	-228	-68
Ecuador	1.42	502	-339	-47	-17	0.26	166	-1	-13	-52
El Salvador	0.56	532	11	-444	1	0.02	424	127	-352	-100
Finland	0.76	188	-4	-24	-60	0.01	304	-81	-42	-80
France	22.63	146	-18	36	-64	1.38	127	1	29	-57
Germany	23.57	76	-15	66	-27	0.60	66	11	47	-23
Greece	1.36	364	-96	-118	-49	1.12	140	35	-39	-36
Guatemala	3.57	278	-73	-18	-87	0.15	70	88	-3	-55
Honduras	4.85	126	64	-15	-75	0.03	458	-230	-68	-61
Hungary	13.93	121	-53	40	-9	0.34	77	-14	19	18
Iceland	0.01	862	14	-745	-31	0.00	6394	-436	-5589	-269
India	40.60	113	58	0	-71	6.37	125	89	0	-114
Indonesia	88.65	60	9	54	-23	0.38	128	-235	233	-26
Ireland	2.52	175	4	-30	-49	0.16	181	4	-31	-54
Israel	0.38	137	41	-65	-12	0.59	175	27	-87	-14
Italy	12.62	89	12	24	-25	1.54	101	-8	29	-22
Japan	0.11	599	-39	-350	-111	0.00	1098	-42	-655	-301
Jordan	0.06	48	-804	832	24	0.03	43	-90	99	48
Rep. of Korea	1.10	67	9	62	-38	0.02	139	-226	223	-36
Madagascar	-1.72	-355	-16	459	12	0.11	254	338	-573	81
Malawi	-0.82	-538	14	480	143	0.02	1119	197	-968	-248
Malaysia	41.66	52	11	61	-24	0.09	119	-418	433	-34
Malta	0.00	-3553	-900	5238	-684	-0.01	-276	67	318	-9
Mexico	2.16	1422	-666	-522	-134	-0.19	-5753	2857	2171	825
Morocco	0.19	2339	-512	-1706	-21	0.03	1620	-204	-1177	-139
Netherlands	27.98	116	-39	48	-25	1.82	119	-44	50	-25
New Zealand	10.63	262	10	-141	-31	0.73	284	-5	-154	-25
Nicaragua	2.22	392	57	-225	-124	0.06	118	44	-57	-5
Nigeria	0.15	418	-639	289	32	0.02	74	-26	27	25
Norway	0.07	610	78	-464	-124	0.00	-3127	245	2466	516
Pakistan	0.20	2554	214	-2082	-587	0.37	2889	350	-2357	-782
Paraguay	20.43	56	2	53	-10	0.11	62	-73	75	36
Peru	1.72	265	0	-121	-44	-0.52	-405	256	221	28

Philippines	1.42	1578	-116	-1147	-216	-0.19	-322	137	252	33
Poland	7.76	153	-18	12	-47	0.15	225	-74	20	-71
Portugal	2.73	83	-17	20	14	0.93	63	-1	11	27
Romania	5.74	215	-14	-58	-42	0.20	176	5	-46	-35
Senegal	-2.30	-305	7	397	1	0.00	122	460	-502	20
Singapore	-14.84	-267	20	336	11	-0.25	-264	33	321	10
Spain	19.45	96	-25	50	-21	7.30	80	3	36	-19
Sudan	-1.63	-373	28	426	19	-1.45	-394	23	452	19
Sweden	0.63	398	-93	-150	-55	0.01	424	-130	-160	-33
Switzerland	0.24	143	-83	79	-40	0.01	136	-60	74	-50
Thailand	20.63	173	-106	59	-26	3.10	129	-25	39	-43
Togo	-0.02	-3727	3	4047	-223	0.00	109	71	-130	50
Trinidad Tobago	-0.67	-269	40	317	11	-0.02	-265	31	310	23
Tunisia	3.54	212	41	-124	-29	0.19	509	-68	-320	-22
Turkey	3.14	186	-32	-40	-13	-1.44	-486	377	136	73
Former USSR	101.21	62	-17	90	-35	3.59	54	13	58	-25
Egypt	0.31	187	44	-94	-36	-0.60	-1351	504	805	142
United Kingdom	6.88	127	-52	57	-33	0.13	511	-619	301	-92
USA	85.83	350	-64	-94	-92	13.46	281	-37	-74	-70
Uruguay	5.26	155	-35	13	-33	0.44	79	89	5	-73
Venezuela	-1.00	-332	23	371	38	-0.11	-279	35	307	38
Former Yugoslavia	1.65	887	-270	-445	-72	-0.03	-902	274	481	247

VWE change: change in virtual water exports (km^{3}), SE: Scale effect (%), CE: Composition effect (%),TE: Trade share effect (%), IE: Intensity effect (%)

Table 10: Change in virtual water imports and decomposition analysis at the country level, 1965-2010

	Green virtual water imports						Blue virtual water imports					
	VWM change(km^3)	SE (%)	CE (%)	TE (%)	LE (%)	IE (%)	VWM change (km^3)	SE (%)	CE (%)	TE (%)	LE (%)	IE (%)
Albania	0.93	123	-96	59	52	-37	0.07	86	-36	34	41	-26
Algeria	12.87	95	19	36	-2	-47	0.91	88	25	32	-1	-43
Argentina	2.27	299	-128	-26	1	-45	-0.01	-2194	1304	222	562	206
Australia	3.87	124	-10	9	13	-37	0.45	107	20	7	1	-36
Austria	6.65	113	-7	13	545	-563	0.28	221	-117	33	795	-832
Barbados	0.07	663	-542	88	-16	-93	0.02	154	-74	15	35	-30
Belgium-Lux.	14.92	343	-72	-60	-23	-89	0.11	4623	-	-1007	-1456	-780
Bolivia	0.35	424	-112	-129	40	-124	0.02	471	79	-143	-194	-113
Brazil	10.62	289	-38	-82	25	-94	0.65	202	32	-37	-34	-63
Bulgaria	0.72	624	-605	164	28	-112	0.03	2592	-	710	-190	-325
Cameroon	1.17	66	18	9	48	-42	0.25	72	81	15	-13	-55
Canada	6.71	447	-57	-198	2	-95	1.13	397	-60	-123	-25	-89
Cent. African Rep.	0.05	142	-156	115	22	-24	0.01	65	76	21	-56	-7
Sri Lanka	2.09	395	96	-261	-49	-80	0.20	651	-67	-440	135	-180
Chile	4.80	219	23	-109	29	-61	0.05	2085	95	-1166	-508	-405
China	142.12	78	-153	137	71	-34	8.10	82	0	150	-72	-60
Colombia	10.38	69	-99	142	18	-31	0.53	82	-120	208	-34	-35
Costa Rica	1.48	100	-22	115	-52	-40	0.20	86	-31	90	-8	-37
Czechoslovakia	2.86	479	-344	52	664	-751	-0.65	-438	466	-53	-55	180
Denmark	3.25	517	-20	-236	-63	-98	0.06	1879	63	-894	-680	-268
Ecuador	2.88	68	11	35	12	-26	0.14	93	8	65	-30	-35
El Salvador	1.46	168	-71	96	-47	-45	0.24	79	-6	31	35	-40
Finland	0.92	916	-313	-307	7	-204	-0.06	-881	496	232	141	113
France	8.39	904	-648	50	-60	-146	-0.33	-3291	2982	-403	312	500
Germany	63.41	74	72	23	15	-85	3.63	87	46	39	16	-88
Greece	5.95	170	-167	143	1	-47	0.19	567	-867	591	-83	-108
Guatemala	2.26	91	8	65	-35	-29	0.33	62	28	31	10	-30
Honduras	1.14	97	-9	97	-44	-41	0.23	64	0	41	29	-34
Hungary	1.52	482	-285	-22	575	-651	-0.18	-681	599	35	-231	377
Iceland	-0.01	-4536	2644	1130	89	774	0.00	-1338	1934	-984	319	169
India	43.30	53	-77	96	46	-18	0.63	221	-	1401	14	-43
Indonesia	26.92	53	-6	63	27	-37	2.22	86	-201	230	39	-53
Ireland	2.81	184	-131	106	-6	-53	0.20	219	-141	131	-50	-59
Israel	4.99	228	-30	-63	30	-65	0.30	358	-72	-104	-14	-68
Italy	22.64	561	-84	-222	-24	-131	1.11	796	-204	-321	-44	-127
Japan	22.07	649	-127	-279	-10	-133	-1.21	-1538	688	705	-3	247
Jordan	3.41	166	-170	142	-1	-37	0.28	290	-399	282	-17	-56
Rep. of Korea	29.36	73	-34	73	31	-43	1.86	121	-136	177	-10	-52
Madagascar	0.27	340	-633	497	-44	-60	0.20	133	-224	142	135	-86
Malawi	0.17	102	106	-49	-3	-55	0.00	175	58	-84	11	-60
Malaysia	5.90	962	-168	-621	49	-122	0.46	571	-287	-42	-32	-109
Malta	-0.01	-	51498	-39491	-7744	10303	0.03	346	-	1529	246	-237
Mexico	39.75	47	19	57	7	-30	4.95	48	21	63	-2	-30
Morocco	8.15	139	-213	225	12	-63	0.54	128	-107	129	-12	-38
Netherlands	35.29	297	-90	-29	-1	-77	0.54	1395	-622	-143	-221	-309
New Zealand	2.07	153	-69	34	21	-40	0.12	374	-267	108	-33	-82
Nicaragua	0.64	156	-110	131	-30	-47	0.13	105	-69	73	29	-39
Nigeria	9.94	58	-3	58	25	-38	0.99	51	107	36	-58	-37
Norway	-0.56	-1956	583	1134	-32	371	-0.05	-1067	405	469	117	176
Pakistan	41.66	43	16	30	42	-32	4.28	44	-55	83	81	-53
Paraguay	0.14	719	-1361	823	52	-132	0.03	115	-47	85	-29	-24
Peru	5.08	234	6	-81	-8	-51	0.24	318	43	-113	-47	-101
Philippines	11.53	120	-5	17	11	-43	0.72	265	-133	46	5	-83

Poland	6.43	344	-149	-18	198	-275	-0.34	-954	686	57	-59	370
Portugal	10.16	106	-62	99	2	-45	1.58	103	-93	99	25	-34
Romania	7.01	58	7	22	36	-23	0.03	3823	-	4166	-920	-469
Senegal	1.59	220	-170	112	4	-66	0.34	198	-161	108	39	-84
Singapore	6.69	238	-43	-61	14	-48	0.12	1352	-611	-476	78	-242
Spain	28.01	147	-3	8	1	-54	1.94	178	-61	22	-9	-30
Sudan	2.91	142	-12	22	-6	-47	0.29	143	-31	35	1	-47
Sweden	0.07	22122	-3455	-13412	-1336	-3819	0.03	2836	-208	-1890	-296	-342
Switzerland	-1.76	-1026	281	702	-23	165	-0.62	-402	236	169	54	44
Thailand	13.60	57	37	6	47	-48	1.11	69	60	0	26	-56
Togo	0.99	52	-8	36	51	-30	0.18	50	38	36	27	-50
Trinidad Tobago	0.30	497	-199	-112	6	-93	0.04	237	-37	-44	2	-59
Tunisia	5.06	117	-15	24	18	-44	0.37	111	-22	24	27	-40
Turkey	22.39	54	-67	98	49	-34	2.58	52	107	79	-107	-31
Former USSR	58.37	51	-79	97	59	-27	2.60	127	-833	854	0	-48
Egypt	27.31	145	-53	46	13	-51	1.28	197	-94	67	-17	-53
United Kingdom	-13.43	-863	94	733	31	105	-2.18	-626	71	535	48	73
USA	28.55	601	-209	-206	23	-110	2.27	522	-119	-177	-45	-81
Uruguay	4.11	70	-44	93	2	-21	0.03	303	-954	819	4	-71
Venezuela	12.63	99	-14	36	-2	-20	0.58	153	-10	64	-60	-48
Former Yugoslavia	7.23	96	-3	84	-7	-69	0.19	272	-367	420	-127	-98

VWM change: change in virtual water imports (km^{3}), SE: Scale effect (%), CE: Composition effect (%), LE: localization effect (%), TE: Trade share effect (%), IE: Intensity effect (%)

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