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Vita and publications

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PUBLICATIONS

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"WTO law and rulings and the EC legal order: a critical review of recent developments of the ECJ case-law", in International Trade Law and Regulation (ITLR), Sweet and Maxwell, London - June 2009 (part 2).

"Transfer pricing e valore in dogana: analisi comparata ed esperienze a confronto", with Avolio, D., in Mayr, S. and Santacroce, B. (eds.) "Valore in dogana e transfer pricing", IPSOA, November 2014.

Abstract

The subject of the three essays is virtual water trade. "Virtual water" is the water used in production of the goods and virtual water import is the water used to produce imported goods. The virtual water concept has been originally proposed by Allan (1997, 1998) building on the Heckscher-Ohlin-Vanek's theory according to which commodity trade can be seen as an implicit exchange in the factors of production embedded in the commodities. The concept of 'virtual water trade' refers to the opportunity to minimize water consumption in water-short countries by increasing imports of products that require a large amount of water in their production cycle (water-intensive products) and limiting the export of water-intensive goods. Virtual water is thus a concept that links water, food, and international trade.

The first essay, titled "International legal aspects of water and virtual water trade", investigates the existing international legal framework applicable to virtual water trade, with the aim of assessing what types of trade rules would promote global water-efficiency. The analysis focuses on three aspects: water-footprint regulatory standards, water-footprint labeling schemes, and water-related agricultural subsidies. The analysis shows that - even if a tendency can be detected from plain rejection, over more nuanced statements, towards a certain 'readiness' for acceptance of environmental protection-driven trade distorting measures - current trade norms do not provide appropriate incentives for the full deployment of water savings achievable through virtual water trade. The analysis also addresses the question of whether certain recent developments in international legal theories (including the "responsibility to protect" doctrine) may act as building blocks in the achievement of global water-efficiency.

The second essay, titled "The relation between interstate conflicts and trade, oil and food: a gravity model and networks' approach", tests from an econometric point of view the relationships between interstate conflicts and control over water flows, through the lens of international trade. Making use of a novel dataset which distinguishes the direction of trade flows between country pairs and the direction of conflicts, the analysis tests the impact of countries' (bilateral and multilateral) trade openness on conflicts and the impact of countries' trade integration on conflicts; trade integration has been measured with a social networks approach and utilizing several networks metrics, such as number of ties, (un)weighted cluster coefficients, overlapping, page rank, as well as with (import) similarity indexes. Results indicate that trade openness plays the most significant role on the probability of wars between country pairs, with opposite effect of bilateral and multilateral trade. As for the strategic role of the different commodities investigated, results confirm that virtual water trade, similarly to oil trade, plays a strategic role in international relations.

The third essay, titled "The water suitcase of migrants" investigates the relation between human migrations and water resources and its role for food security and trade policy in water-scarce countries. It is commonly believed that human migrations are beneficial to the water endowments of origin countries for reducing the pressure on local resources. The analysis shows that such belief is over-simplistic, by reframing the problem by considering the international food trade and the corresponding virtual water flows, which quantify the water used for the production of traded agricultural commodities. By means of robust analytical tools, the analysis shows that migrants strengthen the commercial links between countries, triggering trade flows caused by food consumption habits persisting after migration. Thus, migrants significantly increase the virtual water flows. Finally, a comparison with the water footprint of individuals shows that where the water suitcase of migrants exceeds the water footprint of individuals, migrations turn out to be detrimental to the water endowments of origin countries, with socio-economic and environmental implications for water-scarce and food-insecure countries.

Chapter 1

Introduction

As water resources are unevenly distributed across the globe and in some regions scarcity and droughts are increasing both in frequency and intensity, concerns over them are becoming more and more important on the international agenda[1].

Demographic pressures, economic development, changing diet preferences, urbanization and pollution are all factors putting unprecedented pressure on a renewable but finite resource (essential for all aspects of human life and with no substitutes) particularly in semi-arid and arid regions[2]. Although the total amount of water resources on the planet is enormous and remains constant in a closed hydrological cycle, one has to keep in mind that only 2.5% of all water resources are fresh water resources, and merely 1% is relatively easily accessible for human consumption or for agricultural and industrial demands. Moreover, the accessible fresh water resources are unequally divided over the planet, with only 10 countries disposing over approximately 60% of these resources[3].

Unconstrained water use has grown at global level to a rate more than twice the rate of population increase in the 20th century, to the point where reliable water services can no longer be delivered in many regions; some estimates predict that by 2030 the requirements for fresh water are expected to substantially exceed the currently available and accessible fresh water supplies[4].

Furthermore, global warming is increasingly seen as a factor able to further exacerbate the water-scarcity problems[5]. For many authors, climate change is already causing damages to global food production: a recent study[6] demonstrates a decline in average global production of 3.8% for maize and of 5.5% of wheat, caused by a relatively small raise in temperature over the last 30 years (1980-2010). Other studies indicate severe water shortages in many regions in the middle term due to desertification, while other regions would gain from more rainfalls[7].

Estimates about the number of people who still don't dispose over a reasonable access[8] to safe drinking water largely differ; still, they are all worrisome, even though the UN Millennium Development Goal[9] target of halving the proportion of people without access to safe drinking water has been met in 2010, well ahead of its original 2015 deadline[10].

The 2015 Update Report by the Joint Monitoring Program of UNICEF and WHO on sanitation and drinking water shows an estimate of 663 million people still lacking access to drinking water, and it points out that eight out of ten people without improved access to drinking water yet live in rural areas

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[1] UNEP, (2010), Water Footprint and Corporate Water Accounting for Resource Efficiency, 2010.

[2] FAO (2012), Copying with Water Scarcity, FAO Water Reports 38/2012.

[3] See AQUASTAT: http://www.fao.org/nr/water/aquastat/main/index.stm last visited on July 30th, 2015.

[4] 2030 Water Resources Group, Charting Our Water Future, 5 (2009), New York: McKinsey and Co., International Finance Corporation.

[5] Bates, B., and Kundzewicz, Z. W., (2008), Climate Change and Water, Technical Paper of the International Panel on Climate Change, IPCC Technical Paper IV, IPCC Technical Papers, IPCC, Geneva, Switzerland.

[6] Lobell, D. B., and Wolfram, S., (2011), Climate trends and global crop production since 1980, University of Stanford.

[7] Kundzewicz, Z. W., and Mata, L. J., (2007), Freshwater resources and their management , in Climate Change 2007: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge, Cambridge University Press.

[8] Reasonable access to safe drinking water means a disposal of at least 10 litres per person per day accessible within a range of 1 kilometre, see Howard, G. and Jamie, B., (2003), Domestic Water Quantity, Service, Level and Health. Geneva, World Health Organisation.

[9] UN Millennium Developments Goals Report 2011.

[10] The MDG 7 target regarding access to safe drinking water is tracked in the yearly reports by the Joint Monitoring Program of UNICEF and WHO.

in least developed countries in particular[11]. Some other studies estimate that overall, in between 2 and 7 billion people could face water-scarcity by the year 2050[12].

Currently about 80% of all (fresh) water is used for agriculture and food production, and agricultural products are traded internationally[13]. A full understanding of water use is thus impossible without understanding the international market for agricultural and food products and the drivers of international trade in food.

The concept of 'virtual water trade' refers to the opportunity to minimize water consumption in water-short countries by increasing imports of products that require a large amount of water in their production cycle (water-intensive products) and by limiting the export of water-intensive goods. Water-scarcity problems of arid or semi-arid regions would be alleviated if water-intensive goods are being produced in water-rich regions and non-water-intensive products are being produced in water-scarce regions. Virtual water is thus a concept that links water, food, and international trade.

The concept has been in use for two decades now; recently, it has gained wide attention both in the scientific discussions as well as in the political debate[14]. In fact, the use of the term 'virtual water' increased rapidly and soon this concept had become central to many dialogues relating to water security and water policy. The term has been able to draw attention in the public debate to the notion that serious local water shortages could be very effectively addressed by global economic processes.

The essays presented in the next chapters investigate the international legal framework applicable to virtual water trade, as well as the relations that virtual water trade has with human migrations and with militarized interstate conflicts.

In particular, the first essay investigates to what extent international trade law is already responding to the issues of water scarcity, and which improvements could be made in order to address these issues in a more effective manner. In fact, concerns over the ability of countries to adopt measures aimed at protecting domestic water resources and preventing over-use of these resources are gaining importance. However, apart from debates such as the question of privatization of water services under the GATS Agreement[15], there has been relatively little attention in the literature on the relationship between international trade regulation and trade in virtual water[16].

The second essay investigates the relation between virtual water trade and conflicts, and it aims at showing the strategic nature of trade in virtual water as compared to trade in other strategic commodities (such as oil and gas), non-strategic commodities (such as footwear) and aggregate total trade.

The third essay investigates the relation between human migrations and water resources and its role for food security and trade policy in water-scarce countries. The analysis shows that where the water suitcase of migrants exceeds the water footprint of individuals, migrations turn out to be detrimental to the water endowments of origin countries, with socio-economic and environmental implications for water-scarce and food-insecure countries.

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[11] WHO-UNICEF (2015), Joint Monitoring Program on Water Supply and Sanitation (JMP), Progress on sanitation and drinking water: 2015 update and MDG assessment. The report points out that sustainable water resource limits have been exceeded in Western Asia and Northern Africa, whereas Southern Asia and the Caucasus and Central Asia are approaching water scarcity.

[12] UN–UNESCO, (2003), International Year of Fresh Water - Water for our future, what are the trends?, UNESCO 2003.

[13] Hoekstra, A. Y. and P. Q. Hung (2002), Virtual Water Trade, A Quantification of Virtual Water Flows Between Nations in Relation to International Crop Trade, Value of Water Research Report Series No. 11, Delft, Netherlands, UNESCO-IHE Institute for Water Education.

[14] See Allan, J. A. (2003), Virtual water - the water, food and trade nexus: Useful concept or misleading metaphor? Water International 28(1): 106-113; Chapagain, A. and Hoekstra A.Y. (2004), Water Footprints of Nations, Volume 1 Main Report, Value of Water Research Report Series No. 16, Delft, Netherlands, UNESCO-IHE Institute for Water Education; Wichelns, D. (2004), The policy relevance of virtual water can be enhanced by considering comparative advantages, Agricultural Water Management 66(1): 49-63; Hoekstra, A. Y., and Chapagain, A.K., (2009). Water Footprint Manual, State of the Art 2009, Enschede, Netherlands, Water Footprint Network.

[15] General Agreement on Trade in Services, 1994.

[16] Gualtieri, A.G., (2008), Legal implications of trade in 'real' and 'virtual' water resources, International Environmental Law Research Centre, IELRC Working Paper 2008-02.

Chapter 2

International Legal Aspects of Virtual Water Trade

2.1 Virtual Water Trade: Origin and Definition

'Virtual water' refers to the volume of water used in the full life-cycle of a product since its production, rather than the water contained in the product, and virtual water import is the water used to produce imported goods[17].

The term 'virtual water' has been in use since two decades, since Professor Tony Allan started his studies on the topic of water scarcity in the Middle-East region; he initially referred to the term 'embedded water' to describe the water needed to produce water-rich commodities such as oranges or avocados throughout their complete production cycle, then turned to the term of 'virtual water'.

Prof. Allan was inspired by Israeli economists who had pointed out the dangers in exporting scarce Israeli water: this was in effect what some Israeli economists and government officers argued was happening every time water intensive oranges or avocados were exported from semi-arid Israel[18].

Prof. Allan argued that, rather than entering into conflicts with their neighbors for gaining control over the scarce water resources of the region, the water-poor countries in the Middle-East were able to compensate their water deficits through virtual water trade, i.e. by importing water intensive agricultural products[19].

Hoekstra and the members of the Value of Water Research Group in The Netherlands were able to adding quantitative substance to conceptual acceptance of the 'virtual water' idea by introducing the 'water footprint' concept in the early 2000s[20]; they presented a new methodology for measuring the total amount of water being used in the production process of a specific product ('water footprint' of products), or consumed in a specific country ('water footprint' of nations)[21].

Falkenmark contributed to the debate on 'virtual water' pointing out the fact that soil water is the major water input to the productive sector of agriculture. She specified that the water footprint of products contains a 'green' component (rain-water), a 'blue' component (surface-water and ground-water) and a 'grey' component (used or polluted water). These three components have a different impact on water scarcity since ground-water and surface-water have higher opportunity costs than polluted water[22]: as an example, she pointed out the environmentally beneficial role of soil water in supporting natural vegetation.

The concept of virtual water trade is thereby considered to be an emanation of the comparative advantage theory and has the potential to contribute substantially to global water savings, as it highlights the global potential savings of fresh water resources by means of virtual water trade if certain

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[17] Allan, J. A. (1997), 'Virtual water': a long term solution for water short Middle-Eastern economies?, University of London, SOAS - Water Issues Group.

[18] Allan, J.A., Merrett, S. and Lant, C. (2003), Virtual Water - the Water, Food, and Trade Nexus Useful Concept or Misleading Metaphor?, IWRA, Water International, Volume 28, Number 1, March 2003.

[19] Allan, J. A. (1997), 'Virtual water': a long term solution for water short Middle-Eastern economies?, University of London, SOAS - Water Issues Group.

[20] Hoekstra, A. Y. and P. Q. Hung (2002), Virtual Water Trade, A Quantification of Virtual Water Flows Between Nations in Relation to International Crop Trade, Value of Water Research Report Series No. 11, Delft, Netherlands, UNESCO-IHE Institute for Water Education.

[21] An example which was able to raise wide-spread public interest is the estimated water footprint of a cup of coffee, which is of 140 litres on average; the large majority of these 140 litres of water are utilized to grow the coffee plant. Hoekstra's water footprint methodology also brought under general attention that the amount of water needed in the production process of a particular product can vary considerably, depending upon the production method adopted as well as the location of production. The production of 1 ton of wheat, for example, requires 690 m3 of fresh water in China, 1.654 m3 in India and as much as 2.375 m3 in Russia.

[22] Falkenmark, M. (2003), Freshwater as shared between society and ecosystems: from divided approaches to integrated challenges, Philosophical Transactions of the Royal Society of London B 358(1440): 2037-2049.

products where produced in water-rich regions and/or in those regions where production is more efficient from a water-use perspective, depending on the water requirements for production at these specific locations[23]. Thus, virtual water is considered as a possible solution to water scarcity problems in many arid regions of the world.

Put it differently, Hoekstra says "knowledge about the virtual-water flows entering and leaving a country can cast a completely new light on the actual water scarcity of a country"[24], for example showing that people in countries like Jordan apparently survive owing to import of water-intensive commodities produced elsewhere[25]. The export of water-intensive products, "on the contrary, raises national water demand and thus enhances national water scarcity"[26].

The aim of virtual water trade is to compensate for water shortages through the geographical shift of agricultural production. A 'reality check' suggests this is only to a limited extent happening at the moment[27], whereas current trade in agricultural products mainly conforms to the rules of comparative cost advantages in such factors as labor, land, and capital[28], as well as the supply and demand for economic goods. Examples include:

- the Israeli government's concerns not to 'over-export' water intensive agricultural products, such as oranges, in view of emerging local water scarcity[29];
- among the largest net exporters of virtual water are the U.S., Australia, Canada, Thailand, Argentina, France and Brazil[30];
- some of the largest net importers are Sri Lanka, Japan, the Netherlands, South Korea, China, Spain, Egypt, Germany and Italy[31].

Concerns over the ability of countries to adopt measures aimed at protecting domestic water resources and preventing over-use of these resources are gaining importance. However, apart from debates such as the question of privatization of water services under the GATS Agreement[32], there has been relatively little attention in the literature on the relationship between international trade regulation

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[23] See Oki, T. and Kanae, S. (2004), Virtual water trade and world water resources, Water Science and Technology 49(7): 203-209; Chapagain, A. K. and Hoekstra, A.Y., (2005), Saving Water Through Global Trade, Value of Water Research Report Series No. 17, Delft, Netherlands, UNESCO-IHE Institute for Water Education.

[24] Hoekstra, A.Y. (2010), The Relation Between International Trade and Freshwater Scarcity, World Trade Organization, Economic Research and Statistics Division, Working Paper January 2010.

[25] *Ibid.* – Jordan imports about 5 to 7 billion m3 of virtual water per year, which is in sharp contract with the 1 billion m3 of water withdrawn annually from its domestic water sources.

[26] *Ibid.*

[27] Hoekstra (2010) finds that currently international trade reduces global water use in agriculture by 5%, which is the result of the fact that water-intensive agricultural products are traded, on average, from countries with high to countries with low water scarcity. However, he finds that there would be scope for increasing global water-use efficiency "by including water scarcity as a factor into trade decisions".

[28] Costinot, A. and Donaldson, D. (2012), Ricardo's Theory of Comparative Advantage: Old Idea, New Evidence, American Economic Review - Papers and Proceedings vol. 102(2), May 2012. In this paper the authors assess the empirical performance of Ricardo's theory of comparative advantage by utilizing data on agricultural output and producer prices by country and crop from FAOSTAT and data on productivity from version 3.0 of the Global Agro-Ecological Zones (GAEZ) project run by IIASA and FAO (IIASA/FAO 2012). In fact, in the authors' view, when restricting the analysis to agricultural products it is possible to make Ricardo's theory testable (whereas in conventional settings Ricardo's ideas are difficult to bring to data because it is not possible to observe the relative productivity of productions in different countries / zones) since agriculture, thanks to the work of agronomists, is "a sector of the economy in which scientific knowledge of how essential inputs such as water, soil and climatic conditions map into outputs is uniquely well understood. As a consequence of this knowledge, agronomists are able to predict how productive a given parcel of land would be were it to be used to grow any one of a set of crops". As a result of their analysis, they find that, as far as trade in agricultural products is concerned, Ricardo's theory of comparative advantage "is not just mathematically correct and non-trivial; it also has significant explanatory power in the data".

[29] Allan, J. A. (1997), 'Virtual water': a long term solution for water short Middle-Eastern economies?, University of London, SOAS - Water Issues Group.

[30] The main water-intensive commodities exported from US are oil-bearing crops and cereals; Australia and Canada mainly export cereals and livestock products; Argentina and Brazil mostly export oil-bearing crops, whereas Thailand export rice – see Hoekstra, A.Y. and Chapagain, A.K. (2007), Water footprints of nations: Water use by people as a function of their consumption pattern, Water Resources Management 21(1).

[31] *Ibid.*

[32] General Agreement on Trade in Services, 1994.

and trade in virtual water[33].

In the following sections, the concept of global water savings through virtual water trade will be investigated from an international legal perspective, in order to assess to what extent international legal norms are already responding to the objective of mitigation of water scarcity problems world-wide and how they could be amended in order to better contribute to the achievement of such goal.

The analysis will focus on assessing the compatibility with WTO law of three different topics:

- water-footprint standards;
- water-footprint labeling schemes;
- subsidies related to agriculture and water consumption.

The paper proceeds as follows: Section 1 defines the concept of virtual water trade; Section 2 discusses the international legal aspects of the right to access to water and to food; Section 3 identifies relevant issues of international trade law applicable to the virtual water trade; Section 4 concludes.

2.2 International Legal Scenario on Access to (Fresh) Water and to Food

This section presents a brief overview of the current international legal scenario concerning the human right of access to (fresh) water and to food and related objectives set forth by the international community for mitigating water scarcity problems world-wide and promoting universal access to available (fresh) water resources. This is the paradigm through which the author will analyze and assess in the following sections the existing international trade rules, as they are currently applied, and their impact on virtual water trade; this is also in line with the need, as acknowledged by WTO panelists and Appellate Body's judges, of interpreting WTO law not in "clinical isolation" from other bodies of international law[34].

Incisively, for the matters at hand, former WTO Director-General Pascal Lamy, in a speech on 26 September 2010, said that "trade opening leads to growth, development, poverty reduction, hence trade ensures concrete realization of human rights". He also added that reform of trade in agriculture "would improve access to food, which many see as a human right"[35].

There is a genuine consensus that drinking water as well as water for sanitation services are essential elements of human life on Earth. However, even though the Millennium Development Goal target of halving the proportion of people without access to safe drinking water has been met in 2010, well ahead of the original 2015 deadline, WHO/UNICEF most recent report (2015)[36] estimates that more than 663 million people currently do not have access to drinking water and that by 2025 nearly two-thirds of the countries are expected to be water-stressed. Fresh water will be under additional strain from factors such as population growth and climate change. More than 2.4 billion people are likely to face absolute water scarcity – the point at which the lack of water threatens social and economic development.

2.2.1 The legal bases of the universal human right of access to (fresh) water and to food

The human right of access to water and the right to food have been indirectly recognized in a wide range of international treaties and declarations, including the International Bill of Human Rights;

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[33] Gualtieri, A.G., (2008), Legal implications of trade in 'real' and 'virtual' water resources, International Environmental Law Research Centre, IELRC Working Paper 2008-02.

[34] Please refer to the Appellate Body (AB) ruling in the case *United States – Standards for Reformulated and Conventional Gasoline* (WT/DS2/AB/R), adopted 29 April 1996, where the judges acknowledged that *"(t)he general rule of interpretation [as set out in Article 31(1) of the Vienna Convention on the Law of Treaties] has attained the status of a rule of customary or general international law. As such, it forms part of the "customary rules of interpretation of public international law" which the Appellate Body has been directed, by Article 3(2) of the DSU, to apply in seeking to clarify the provisions of the General Agreement and the other "covered agreements" of the Marrakesh Agreement Establishing the World Trade Organization (the "WTO Agreement"). That direction reflects a measure of recognition that the General Agreement is not to be read in clinical isolation from public international law."*

[35] Lamy's speech can be found at https://www.wto.org/english/news_e/sppl_e/sppl172_e.htm, last visited on July 30th, 2015.

[36] WHO-UNICEF (2015), Joint Monitoring Program on Water Supply and Sanitation (JMP), Progress on sanitation and drinking water: 2015 update and MDG assessment.

as an example, article 24, paragraph 2, of the Convention on the Rights of the Child[37] requires States parties to combat disease and malnutrition through the provision of adequate nutritious foods and clean drinking-water[38]. Similar principles are established for older persons by the United Nations Principles for Older Persons[39].

Furthermore, a number of other relevant declarations and treaties originate from the Earth's Summit in Rio (1992) and from the resulting environmental and climate change conferences, addressing the issues of access to water and water resources management and their interplay with environmental protection and climate change mitigation, in particular:

- Agenda 21 (1992);
- Millennium Developments Goals - MDGs (2000);
- Johannesburg Plan of Implementation – JPOI (2002);
- Dushanbe Water Appeal (2003).

Appendix I lists the main objectives of each of these treaties and declarations, for what concerns: access to safe drinking water; protection of water resources, water quality and aquatic ecosystems; integrated water resources management; water resources assessment; and water and sustainable urban development.

However, only during the last decade, the right to water has been specifically addressed multilaterally, within the UN umbrella. In November 2002, the UN Committee on Economic, Social and Cultural Rights adopted General Comment No. 15 on the right to water[40]. Article I.1 states that "(t)he human right to water is indispensable for leading a life in human dignity. It is a prerequisite for the realization of other human rights"[41].

Comment No. 15 also defined the right to water as the right of everyone to sufficient, safe, acceptable and physically accessible and affordable water for personal and domestic uses: "(t)he human right to water entitles everyone to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses. An adequate amount of safe water is necessary to prevent death from dehydration, to reduce the risk of water-related disease and to provide for consumption, cooking, personal and domestic hygienic requirements"[42].

Article 11, paragraph 1, of the Covenant specifies a number of rights emanating from, and indispensable for, the realization of the right to an adequate standard of living including adequate food, clothing and housing. The use of the word "including" indicates that this catalogue of rights was not intended to be exhaustive. It can therefore be argued that the right to water would fall within the category of guarantees essential for securing an adequate standard of living, particularly since it is one of the most fundamental conditions for survival.

The right to water is also inextricably related to the right to the highest attainable standard of health (art. 12, para. 1) and the rights to adequate housing and adequate food (art. 11, para. 1).

Furthermore, the UN Committee acknowledged that water is required for a range of different purposes, besides personal and domestic uses, to realize many of the Covenant rights, therefore one may also consider the right to water as a prerequisite for the achievement of other human rights. For instance, it is indicated that water is necessary to produce food (right to adequate food) and ensure environmental hygiene (right to health). Priority should also be given to the water resources required to prevent

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[37] Adopted and opened for signature, ratification and accession by General Assembly resolution 44/25 of 20 November 1989; it entered into force on 2 September 1990.

[38] Art. 24, para.2, states "States Parties shall pursue full implementation of this right and, in particular, shall take appropriate measures: (….); *c)* (t)o combat disease and malnutrition, including within the framework of primary health care, through, inter alia, the application of readily available technology and through the provision of adequate nutritious foods and clean drinking-water, taking into consideration the dangers and risks of environmental pollution (…)".

[39] Adopted by General Assembly resolution 46/91 of 16 December 1991. Article 1 provides that "(o)lder persons should have access to adequate food, water, shelter, clothing and health care through the provision of income, family and community support and self-help".

[40] UN Economic and Social Council, General Comment No. 15 (2002), "The right to water (arts. 11 and 12 of the International Covenant on Economic, Social and Cultural Rights)".

[41] *Ibid.*

[42] *Ibid.*

starvation and disease, as well as water required to meet the core obligations of each of the Covenant rights.

In the Committee's view, there are a number of core obligations in relation to the right to water which are of immediate effect:

- "To ensure access to the minimum essential amount of water, that is sufficient and safe for personal and domestic uses to prevent disease;
- To ensure the right of access to water and water facilities and services on a non-discriminatory basis, especially for disadvantaged or marginalized groups;
- To ensure physical access to water facilities or services that provide sufficient, safe and regular water; that have a sufficient number of water outlets to avoid prohibitive waiting times; and that are at a reasonable distance from the household;
- To ensure personal security is not threatened when having to physically access to water;
- To ensure equitable distribution of all available water facilities and services;
- To adopt and implement a national water strategy and plan of action addressing the whole population; the strategy and plan of action should be devised, and periodically reviewed, on the basis of a participatory and transparent process; it should include methods, such as right to water indicators and benchmarks, by which progress can be closely monitored; the process by which the strategy and plan of action are devised, as well as their content, shall give particular attention to all disadvantaged or marginalized;
- To monitor the extent of the realization, or the non-realization, of the right to water;
- To adopt relatively low-cost targeted water programs to protect vulnerable and marginalized groups;
- To take measures to prevent, treat and control diseases linked to water, in particular ensuring access to adequate sanitation"[43].

The conclusions and recommendations by the UN Committee contained in the Comment No. 15 gained wide support in the public debate; not long after, in 2010, the UN General Assembly and the Human Rights Council put forward resolutions where access to water and sanitation services is considered part of human rights[44].

In particular, through Resolution 64/292, the United Nations General Assembly explicitly recognized the human right to water and acknowledged that clean drinking water and sanitation services are essential to the realization of all human rights. The resolution calls upon States and international organizations to provide financial resources, help capacity-building and technology transfer to help developing countries to provide safe, clean, accessible and affordable drinking water and sanitation services for all. The resolution also points out that this right can only be realized as a result of well-organized and consistent economic, regulatory and social activities, which have their costs.

The right of access to (fresh) water contains both freedoms and entitlements. The freedoms include the right to maintain access to existing water supplies necessary for the right to water, and the right to be free from interference, such as the right to be free from arbitrary disconnections or contamination of water supplies. By contrast, the entitlements include the right to a system of water supply and management that provides equality of opportunity for people to enjoy the right to water. The manner of the realization of the right to water must also be sustainable, ensuring that the right can be realized for present and future generations.

While the Comment No. 15 acknowledges that the adequacy of water required for fulfilling the right to water may vary according to different conditions, minimum standards are specifically set out, in terms of availability, quality, physical and economic accessibility to water.

Even though the Covenant provides for progressive realization and acknowledges the

[43] UN Economic and Social Council, General Comment No. 15 (2002), "The right to water (arts. 11 and 12 of the International Covenant on Economic, Social and Cultural Rights)".

[44] The human right to water and sanitation, United Nations General Assembly resolution 64/292 (A/RES/64/292), adopted 28 July 2010; Human Rights and access to safe drinking water and sanitation, United Nations Human Rights Council resolution 15/9 (A/HRC/RES/15/9), adopted 30 September 2010.

constraints due to the limits of available resources, it also imposes on States parties various obligations which are of immediate effect. States parties have immediate obligations in relation to the right to water, such as the guarantee that the right will be exercised without discrimination of any kind (art. 2, para. 2) and the obligation to take steps (art. 2, para.1) towards the full realization of articles 11, paragraph 1, and 12[45]. States parties have a constant and continuing duty under the Covenant to move as expeditiously and effectively as possible towards the full realization of the right to water.

The right to water, like any human right, imposes three types of obligations on States parties: obligations to respect, obligations to protect and obligations to fulfill[46].

(a) Obligations to respect: it requires that States parties refrain from interfering directly or indirectly with the enjoyment of the right to water. The obligation includes, inter alia, refraining from engaging in any practice or activity that denies or limits equal access to adequate water; arbitrarily interfering with customary or traditional arrangements for water allocation; unlawfully diminishing or polluting water; limiting access to, or destroying, water services and infrastructure as a punitive measure, for example, during armed conflicts in violation of international humanitarian law.

(b) Obligations to protect: it requires State parties to prevent third parties from interfering in any way with the enjoyment of the right to water. Third parties include individuals, groups, corporations and other entities as well as agents acting under their authority. The obligation includes, inter alia, adopting the necessary legislative measures to restrain, for example, third parties from denying equal access to adequate water; and polluting and inequitably extracting from water resources, including natural sources, wells and other water distribution systems.

(c) Obligations to fulfill: this can be disaggregated into various obligations to facilitate, promote and provide. For instance, State parties are required to take positive measures to assist individuals and communities to enjoy the right, and they are also obliged to provide the right when individuals or a group are unable, for reasons beyond their control, to realize it themselves.

Article 2, paragraph 1, and articles 11, paragraph 1 of the Covenant, also require that States parties recognize the essential role of international cooperation and assistance and take joint actions to achieve the full realization of the right to water.

International cooperation requires States parties to refrain from actions that interfere, directly or indirectly, with the enjoyment of the right to water in other countries[47]. Therefore, the activities which a country may operate within its territorial jurisdiction should not deprive another country of the ability to realize the right to water for its citizens.

States parties should refrain at all times from imposing embargoes or similar measures, that prevent the supply of water, as well as goods and services essential for securing the right to water. Furthermore, water should never be used as an instrument of political and economic pressure.

2.2.2 Bilateral, regional and multilateral treaties on transboundary river basins

The case of transboundary basins represents the classical set-up emphasizing the need for international cooperation among the States sharing the basins (so-called "riparian States") in order to prevent possible conflicts over the management, use and conservation of the shared resource[48].

A recent survey from UN-WATER Agency[49] shows that approximately 40 per cent of the world's population lives in river and lake basins that comprise two or more countries and, perhaps even more significantly, over 90 per cent lives in countries that share basins. The existing 263 transboundary[50] lake

[45] The human right to water and sanitation, United Nations General Assembly resolution 64/292, A/RES/64/292, adopted 28 July 2010; Human Rights and access to safe drinking water and sanitation, United Nations Human Rights Council resolution 15/9, A/HRC/RES/15/9, adopted 30 September 2010.

[46] De Schutte, O., (2010), International Human Rights Law, Cambridge, CUP, 2010.

[47] *Ibid.*

[48] See Toset, H.P.W., and Gleditch, N. P., and Hegre, H., (2000), "Shared rivers and interstate conflicts", Political Geography, 19(2000), 971-996; Gleditch, N.P., (2012), "Whither the weather? Climate change and conflicts", Journal of Peace, 49(1), 3-9.

[49] UN-Water, (2008), "Transboundary Waters: Sharing Benefits, Sharing Responsibilities", Thematic Paper 2008.

[50] The term "transboundary basin" in this paper refers to transboundary rivers, lakes, inland water as well as aquifers, (whereas open oceans, territorial seas and coastal waters are excluded). While it can affirmed that cooperation over transboundary basins has a long history, the same cannot be said about transboundary aquifers, whose joint management is still in its infancy.

and river basins cover nearly one half of the Earth's land surface and account for an estimated 60 per cent of global (fresh) water flows. A total of 145 States include territories within such basins, and 30 countries lie entirely within them. In addition, about 2 billion people world-wide depend on groundwater, which includes approximately 300 transboundary aquifer systems.

These data reported from the UN-WATER Agency stress how transboundary basins and aquifers tie together the vital and economic interests and the standards of living of a large share of global population, at the same time providing common ground and conditions for effective cooperation among different countries as well as potential sources of tension and conflicts among them.

History shows that cooperation on transboundary basins has always been wide-spread over many regions in the world and that water more often unites than divides peoples and societies. In fact, since 1948, there has been a real proliferation of bilateral or regional treaties on transboundary water resources management: approximately 295 international water treaties were concluded[51], showing that riparian countries have a long history in acknowledging that cooperation and joint efforts better serve their common interests rather than conflicts[52].

However, this is not always the case: there are still numerous watercourses and aquifers, without adequate legal frameworks for cooperation[53]. In addition, not always the existing treaties are able to provide an effective framework for cooperation between riparian countries to promote integrated water resources management, most often due to lack of technical capacity to implement the agreements as well as lack of political will in dealing with the political and social costs of such agreements.

In addition to the bilateral treaties, there are a number of multilateral legal sources providing for a framework for cooperation between riparian countries in transboundary basins.

In 1992, the UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention) was adopted in Europe[54], which served as the basis for adoption of many bilateral and multilateral agreements, including the 1994 Convention on the Cooperation for the Protection and Sustainable Use of the Danube River[55]. The regional success of the Water Convention has convinced its parties to adopt an amendment to the Convention opening it up for accession by all United Nations member States as from February 2013.

In 1997, the United Nations General Assembly adopted the Convention on the Non-Navigational Uses of International Watercourses[56], which entered into force in August 2014, whose core principles, such as equitable and reasonable utilization and the no-harm rule, are already part of international customary law.

Both Conventions promote the principle of equitable and reasonable use of transboundary watercourses, and establish substantive and procedural obligations to guide countries in sustainably managing and sharing water resources[57].

2.2.3 International legal doctrines' developments and their applicability to access to (fresh) water and to food

In the previous sub-sections a brief 'static' description was presented of the international legal scenario on the recognition of the universal human right of access to safe (fresh) water and to food. The present section discusses a more 'dynamic' approach on how to further provide life and substance to

[51] Only as examples, we may cite here the 1960 Indus Water Treaty; the 1978 Great Lakes Water Quality Agreement; the 1991 Pakistan Water Apportionment Accord; the 1995 Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin; the 1995 Protocol on Shared Watercourse Systems in the Southern African Development Community Region; the 1996 Mahakali and Ganges treaties; the 2003 African Convention on the Conservation of Nature and Natural Resources.

[52] UN-Water, (2008), "Transboundary Waters: Sharing Benefits, Sharing Responsibilities", Thematic Paper 2008.

[53] In total, 158 of the 263 international river basins, plus transboundary aquifer systems, lack any type of treaties between riparian countries or other legal framework for cooperation in water resources management.

[54] United Nations Economic Commission for Europe – adopted in Helsinki, on March 17th, 1992.

[55] Signed in Sofia, on June 29th, 1994.

[56] Adopted by the General Assembly of the United Nations on May 21st, 1997. Entered into force on August 17th, 2014 - General Assembly resolution 51/229, annex, Official Records of the General Assembly, Fifty-first Session, Supplement No. 49 (A/51/49).

[57] Weiss, E.B., and Slobodian, L., (2014), Virtual Water, Water Scarcity, and International Trade Law, Journal of International Economic Law, 17, 717-737.

these human rights (and to the corresponding obligation on State parties and non-State actors alike), in light of two international legal doctrines: the doctrine of 'common concerns of mankind'[58] and the doctrine of 'responsibility to protect'[59].

Both are premised on a belief in the mutual interest of all people in the well-being of all people without regard to political boundaries or legal jurisdictions. As cosmopolitan concepts, they both call upon States to address situations of the human condition that are extra-territorial: the 'responsibility to protect' and the 'common concern' doctrines thus share the need to overcome traditional approaches to state sovereignty[60].

In fact, the Westphalian system of sovereign States relies on the strong notion of territoriality. This implies the territorial State's jurisdiction over resources physically located within its borders. However, two types of problems are left unsolved by this system: one type of problems refers to State's actions taken within its territory but having extraterritorial effects, harming other States' resources, as in the case of transboundary pollution or over-fishing; another type of problems refers to cases where a sovereign State abuses of resources within its own territory. The deforestation of areas with abundant biodiversity or the abuse of citizens' human rights are all examples of actions that are "domestic concerns" for sovereign governments when sovereignty is defined territorially. Under an increasingly cosmopolitan view of international relations, however, such abuses could – if severe enough – actually be a violation of the interests of the international community, and thus be characterized as 'common concerns'. But for too long, the interests of the international community were no match against rights of the sovereign State.

"Common concerns" can only be addressed by means of communal efforts at multiple levels with each actor recognizing the significance of its actions as a part of the overall solution.

The principle of "common concern" therefore not merely serves as a foundation of co-operation, but also as a foundation for joint responsibilities in the production or in the conservation of global public goods[61]. It therefore offers a foundation for future obligations to cooperate. Any situation which can be considered a problem that (i) concerns the entire international community and that (ii) cannot be solved by a single member of the community affected within its own borders, should be considered one in which the international community has a responsibility to protect, assist, and/or respond[62].

The doctrine of 'responsibility to protect' made the path breaking jump to a duty to act outside a state's own territory to prevent, halt, or remedy abuses.

The 'responsibility to protect' is both a principle and a concept. As a principle, it is a norm that is circumscribed by the international community's acceptance of responsibility to protect populations facing mass human rights violations. This norm arose out of the broader concept of the need to rescue populations facing threats to their security. The concept of 'responsibility to protect', then, is recognition that where large numbers of people are threatened with severe and avoidable harm, inaction by those who could assist in reducing that threat is not legitimate[63].

'Responsibility to protect' as a concept had its origins in the African Union's Constitutive Act[64],

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[58] Cottier, T. and Schefer, K.N., (2012), "Responsibility to Protect and the Emerging Principle of Common Concern", NCCR/WTI Working Paper No 2012/29, June 2012.

[59] Petersman, E.U., (2012), "Human Rights and International Economic Law: Common Constitutional Challenges and Changing Structures", EUI Working Papers LAW 2012/07.

[60] Cottier, T. and Schefer, K.N., (2012), "Responsibility to Protect and the Emerging Principle of Common Concern", NCCR/WTI Working Paper No 2012/29, June 2012.

[61] There is not yet a definitive consensus on what constitutes a global public good; a tentative generic definition of global public goods could be the one of goods with benefits that extend to all countries, people and generations. As it is evident, this definition weakens the classical definition of 'public good' given by Samuelson as goods defined by two features: non-rivalry in consumption and non-excludability. For an interesting and extensive discussion of the alternative theories for defining global public goods please refer to Sankra, U., (2008), Global Public Goods, Madras School of Economics Working paper 28/2008, and to the 2006 report from the International Task Force on Global Public Goods, "Meeting Global Challenges".

[62] Cottier, T. and Schefer, K.N., (2012), "Responsibility to Protect and the Emerging Principle of Common Concern", NCCR/WTI Working Paper No 2012/29, June 2012.

[63] Petersman, E.U., (2012), "Human Rights and International Economic Law: Common Constitutional Challenges and Changing Structures", EUI Working Papers LAW 2012/07.

[64] The Constitutive Act of the African Union: adopted in 2000 at the Lome Summit (Togo), entered into force in 2001.

which establishes "the right of the Union to intervene in a Member State pursuant to a decision of the Assembly in respect of grave circumstances, namely: war crimes, genocide and crimes against humanity". Labeled the "non-indifference" principle, the African Union's right to intervene is a call for regional governments to respond to serious human rights abuses occurring in the territory of others. This represented a clear switch from the non-intervention principle in case of human rights violations[65].

As a principle, 'responsibility to protect' has been affirmed repeatedly by the UN Security Council. However, so far its dictates are strictly limited to situations in which "mass atrocity crimes" are taking place or are likely to take place. The scope of "mass atrocity crimes" so far accepted by the United Nations members is only limited to the following four crimes: large scale ethnic cleansing, genocide, war crimes, and crimes against humanity[66].

The introduction of a responsibility to protect as a norm binding states does not merely amount to a step along the existing trajectory of international legal development. In fact, it is opinion of some authors that there have been few international principles developed over the last 50 years that would, if implemented, so radically alter the existing legal framework of state relations as that of the emerging responsibility to protect[67]: in fact, a paradigm change[68].

It is hoped that these doctrines will continue to gain momentum within the international community and among political leaders, to also cover common objectives such as the protection of essential natural resources, including water.

Against this general background, the next section will discuss trade rules' implications for virtual water trade. A necessary premise is the consideration that currently there is an imbalance between international trade agreements (under the WTO system) and international agreements on sustainable water use, being the former strong, well-routined and detailed, quite sophisticated and with binding effects on countries world-wide, whereas the latter are weak, unsophisticated, and with no 'teeth' or binding effects apart from the limited deterrent of reputational damages. Moreover, at the moment there are no international agreements of the type that have the strength to restrict trade in cases where it negatively affects local water systems, nor exist international agreements regulating sustainable water use in the production of goods or services.

Even if, as pointed out by Hoekstra[69], in the perspective of the WTO, 'free trade' is not at odds with 'green trade', and national governments who have (voluntarily) negotiated WTO rules as well as international environmental agreements could use the latter to solve eventual disputes among them, still this imbalance could possibly have a strong impact in all those cases where parties are not signatory of environmental agreements or when the obligations under trade rules go beyond the corresponding obligations under the environmental agreements. In fact, as reported by the WTO, if trade barriers could be raised with (a mere) reference to national regulations, "then any country could ban imports of a product from another country merely because the exporting country has different environmental, health and social policies from its own. This would create a virtually open-ended route for any country to apply trade restrictions unilaterally – and to do so not just to enforce its own laws domestically, but to impose its own standards on other countries"[70].

The likely consequence which one could expect is that in all those cases where the objectives of free trade are in contrast with the goal of water resources protection, the forum chosen for the dispute

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[65] *Ibid.*

[66] UN Secretary-General Ban Ki Moon's 2009 report, "Implementing the Responsibility to Protect", paragraph 10(b) states that "The responsibility to protect applies, until Member States decide otherwise, only to the four specified crimes and violations: genocide, war crimes, ethnic cleansing and crimes against humanity. To try to extend it to cover other calamities, such as HIV/AIDS, climate change or the response to natural disasters, would undermine the 2005 consensus and stretch the concept beyond recognition or operational utility".

[67] Petersman, E.U., (2012), "Human Rights and International Economic Law: Common Constitutional Challenges and Changing Structures", EUI Working Papers LAW 2012/07.

[68] Cottier, T. and Schefer, K.N., (2012), "Responsibility to Protect and the Emerging Principle of Common Concern", NCCR/WTI Working Paper No 2012/29, June 2012.

[69] Hoekstra, A.Y., (2010), The relation between international trade and freshwater scarcity, WTO Staff Working Paper ERSD-2010-05, January 2010.

[70] WTO, (2008), Understanding the WTO, Fourth edition, WTO, Geneva, Switzerland, 2008.

would be the WTO, and panelists and eventually the judges of the Appellate Body will be adjudicating the dispute on the basis of WTO trade rules[71].

2.3 WTO Legal Framework and Trade in Virtual Water

This section investigates the current relevant WTO legal framework, in order to assess to what extent it is already responding to the issues of water scarcity, and which improvements could be made in order to respond to these concerns in a more adequate and effective manner.

Possible implications of WTO rules on trade in virtual water appear to be wide-ranging: as a first example, one question which would immediately come to mind concerns the compatibility with WTO law of eventual export control measures, or export bans, on water-intensive products, possibly adopted by water-scarce countries on the basis of serious concerns over conservation of their domestic water resources.

In fact, the main purpose of the WTO is the liberalization of international trade through the elimination of trade restrictions. The cornerstone principles are expressed by articles I, III and XI of the GATT Agreement[72]. A possible conflict between export control measures and GATT rules could derive from the provisions of article XI, paragraph 1, GATT, preventing countries from instituting or maintaining prohibitions or restrictions on export of products to other contracting parties other than duties, taxes or other charges.

However, possible exceptions could apply (and justify the export control measure) when considering the provisions of both article XX - whose provisions will be discussed in details *infra* - and article XI, paragraph 2(a), which set forth a list of (temporary) exceptions which could apply in our case[73]. When instituting export restrictions or prohibitions to prevent or relieve critical shortages of foodstuff, countries must 'give due consideration to the effects of such prohibition or restriction on importing states' food security'. Since water is undoubtedly essential in preventing or relieving shortages of foodstuffs and can be considered a product essential to the exporting state, water exports could be temporarily excluded from the scope of article XI, paragraph 1[74]. Yet, the exporting state, when applying the export restriction, would still be required to balance its own food security interests with those of the importing state(s).

Other possible questions to be investigated concern the compatibility of regulatory measures discriminating products at importation on the basis of their water-footprint, or the impact of tariffs on trade of agricultural products[75] or, again, the impact of subsidies on the international market for agricultural products.

Three main topics will be analyzed in this paper:

- the compatibility with WTO rules of regulatory measures relating to process and production methods ('ppm') distinctions on the basis of products' water footprint;
- the compatibility with WTO rules of products' labeling requirements;
- the legal status of water-related subsidies under WTO-covered agreements.

2.3.1 WTO compatibility of water footprint–based regulatory measures

There is now a widespread awareness over the fact that there exist large variations in the

[71] Hoekstra, A.Y., (2010), The relation between international trade and freshwater scarcity, WTO Staff Working Paper ERSD-2010-05, January 2010.

[72] General Agreement on Tariffs and Trade, 1947.

[73] Article XI, paragraph 2(a), GATT sets forth a temporary exception to the provisions of paragraph 1 with respect to "export prohibitions or restrictions temporarily applied to prevent or relieve critical shortages of foodstuffs or other products essential to the exporting contracting party."

[74] Gualtieri, A.G., (2008), Legal implications of trade in 'real' and 'virtual water' resources, IELRC Working Paper 2008-02.

[75] In particular, the mandate of the Doha round of trade negotiations includes the reduction of import tariffs for agricultural products, potentially leading to an increased virtual water trade: whether this would be beneficial or detrimental to the issues of water scarcity and water efficiency remains uncertain in a time where water does not have a price reflecting its full-costs – for an extensive discussion, please refer to Weiss (2014).

amounts of water needed to produce the same agricultural product, depending upon the climate of the region where it has been produced and the technology utilized[76].

One could therefore think of treating products in a different way (for example through import taxation), according to the amount of water that has been used to produce them, or on the basis of the relative amounts of water components (blue, green, grey, having different opportunity costs) consumed in their production. Within the WTO legal framework, a distinction of apparently identical products based on their production methods is known as non-product related process and production method ('ppm')[77]. This would potentially allow for a differentiation of products for environmental purposes, on the basis of products' water footprint.

Therefore, regulations and standards that promote efficient use of water could be used to help manage international trade in virtual water and so contribute to global water-efficiency. National water efficiency standards that apply to both domestically produced and imported products would preclude those markets to products which do not meet such standards, putting pressure on producers to use more water-efficient technologies, or relocate to more water-efficient locations[78].

In practice, this would imply that the non-discrimination principle would hold only for similar products that are considered also similar in terms of their (environmental) impact along their supply chain; countries would be free to discriminate imports of a certain product from countries that can guarantee that the product's water footprint is below a certain threshold, or meets certain standards. Of course, the same treatment should be accorded – according to the non-discrimination principle – to all countries that can give that same guarantee[79].

In the context of virtual water trade and international trade law, a relevant question is therefore whether identical agricultural products, though produced with a significant difference in fresh water use throughout their production cycle, could be considered as 'different products' for regulatory purposes. For example, the production of 1 ton of seed cotton in Australia requires 2.178 m3 of fresh water while the production of 1 ton of seed cotton in Uzbekistan requires 4.360 m3 of fresh water, and the production of 1 ton of seed cotton in India as much as 8.662 m3 of fresh water[80]. If these products, having the same physical aspect, are to remain 'like' products for GATT purposes, then they cannot be treated differently. If, on the other hand, they may be considered as different products, due to the fact that they have different impacts on global fresh water resources, then they could be treated differently, giving the appropriate incentive to water-efficient productions.

A regulatory system for water efficiency would require methods for accurately and consistently measuring virtual water content across the life cycle of the products. It would have to set a water efficiency threshold at a high enough level to allow sufficient production to meet the need, but a low enough level to put some pressure on producers to adopt water-efficient technologies. Furthermore, implementation of virtual water efficiency regulations would require fair and continuous monitoring to ensure that products coming from the various countries of origin meet the water efficiency standards set. Related implementation costs could be diminished by adopting systems for self-reporting by producers and intermediaries, with some mechanism for third party certifications[81].

2.3.1.1 The WTO general obligation of 'non-discrimination' between 'like products'

Non-discrimination is clearly the driving concept informing WTO law and policy. Two main

[76] See Wichelns (2004).

[77] Cottier, T. and Oesch, M. (Eds.), (2005), International Trade Regulation, Law and Policy in the WTO, the European Union and Switzerland, Bern, Switzerland/London, UK, Staempfli Publishers/Cameron May, p. 412-419.

[78] Weiss, E.B., and Slobodian, L., (2014), Virtual Water, Water Scarcity, and International Trade Law, Journal of International Economic Law, 17, 717-737.

[79] Hoekstra, A. Y., (2010), The relation between international trade and freshwater scarcity, WTO Staff Working paper ERSD-2010-05, January 2010.

[80] Hoekstra, A. Y. and Chapagain, A.K., (2008), Globalization of Water: Sharing the Planets Freshwater Resources, Oxford, UK, Wiley-Blackwell Publishing.

[81] Weiss, E.B., and Slobodian, L., (2014), Virtual Water, Water Scarcity, and International Trade Law, Journal of International Economic Law, 17, 717-737.

principles of non-discrimination apply within the WTO legal system: the most-favoured-nation (MFN)[82] treatment obligation and the national treatment (NT)[83] obligation.

The most-favoured-nation principle dictates that all WTO member States must be treated on an equal footing and grant each other equal treatment of like products originating or destined for the territories of all other members.

The national treatment principle implies that once goods have entered into a market, equal treatment must be applied to foreign and domestic goods. Both principles apply to *de jure* discriminations and to *de facto* discriminations alike.

As incisively remarked by the Appellate Body in *US – Section 211 Appropriations Act* [84], "*(l)ike the national treatment obligation, the obligation to provide most-favoured-nation treatment has long been one of the cornerstones of the world trading system. For more than fifty years, the obligation to provide most-favoured-nation treatment in Article I of the GATT 1994 has been both central and essential to assuring the success of a global rules-based".*

There is no definition in the GATT Agreement provisions of what constitute 'like' products and which exact criteria should be used to determine whether two products originating in two different countries are 'like' or not (in the latter case, they could be treated differently, independently of any social or environmental concerns).

Generally, the term 'like' refers not only to the physical characteristics of products but also to 'directly competitive or substitutable' products. Early criteria for determining whether products are to be considered as 'like' were determined in one of the first GATT case-law and since then called 'the border tax adjustment criteria'[85]: 'physical characteristics', 'consumer's tastes and habits', and 'the products end-uses in a given market'. 'Tariff classification' was then added as a complementary criterion[86]. A consensus was reached upon a narrow interpretation of 'like products'. For example, in one of the first cases brought before a GATT dispute settlement panel, it was determined that 'shochu' and 'vodka' were considered to be 'like products' for the purposes of the GATT because they were considered to be 'directly competitive'[87]. Shochu and vodka were thus to be treated without any discrimination in tariffs and taxes, when entering the local market. This narrow interpretation of the 'like products' criterion favoured the goals of fighting protectionist measures. On the other hand, considerations external to trade, such as environmental concerns, were not taken into account in this early GATT jurisprudence.

Some scholars insist on the fact that there has been no clear prohibition in GATT (and consequently in WTO) case-law on the use of ppm criteria in order to determine if a product is a 'like product' for WTO purposes[88]. However, a distinction has to be made between product-related ppms and non-product related ppms. The former production methods change the physical characteristics of the end-product, while the latter doesn't. Non-product related process and production methods ('npr-ppms'), under which environmental concerns can best be addressed, and under which also water footprint standards or 'water-ppms' can be categorized, may appear less likely to be accepted as a criterion for the classification of 'unlike' products for WTO purposes. However, since the Appellate Body's report in the *EC – Asbestos* case, investigation should occur on a case to case basis[89]. Considering forecasted future global water scarcity problems, governments' aim to discourage water intensive

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[82] Article I, GATT Agreement.

[83] Article III, GATT Agreement.

[84] See *US – Section 211 Omnibus Appropriations Act of 1998*, Appellate Body Report (WT/DS176/AB/R), 2 January 2002, para. 297.

[85] See *Border Tax Adjustment*, Report of the Working Party, 2 December 1970, para. 18.

[86] Cottier, T. and Oesch, M. (Eds.), (2005), International Trade Regulation, Law and Policy in the WTO, the European Union and Switzerland, Bern, Switzerland/London, UK, Staempfli Publishers/Cameron May.

[87] See *Japan – Custom Duties, Taxes and Labelling Practices on Imported Wines and Alcoholic Beverages*, Report of the Panel, 10 November 1987.

[88] Charnovitz, S. (2002), The Law of Environmental "PPMs" in the WTO: Debunking the Myth of Illegality, Yale Journal of International Law (YJIL) 27; Howse, R. and D. H. Regan (2000), The Product/Process Distinction – An Illusory Basis for Disciplining 'Unilateralism' in Trade Policy, European Journal of International Law, 11(2): 249-289.

[89] See *European Communities - Measures Affecting Asbestos and Asbestos Containing Products,* Appellate Body Report, (WT/DS135/AB/R), 12 March 2001, para. 21.

productions while favouring water-efficient productions on the global level may appear a legitimate policy's objective[90].

Would then a non-product related water footprint standard, or a water-ppm, stand the test of non-discrimination in a dispute settlement proceeding? The question is linked with the degree of acceptability of environmental concerns under international trade law. Although the germ for acceptance of legitimate environmental concerns and criteria under WTO law can already be found in the preamble of the Marrakesh Agreement establishing the WTO itself[91], WTO case-law is still struggling with this matter, allegedly out of concern for disguised protectionist measures.

In the absence of specific case-law directly addressing the topic of water-related regulatory measures differentiating products on the basis of their water-footprint, it is important to discuss the most relevant GATT/ WTO case-law regarding the legal treatment of ppms and its possible consequences for the setting of water footprint standards. It has to be noted immediately that, under article XX GATT, exceptions could possibly be granted, for example, for measures aimed at the protection of human, animal or plant life or health[92], or the conservation of exhaustible resources[93]. Besides the direct acceptance under articles I or III GATT via the 'like products' distinction, some of the provisions of article XX could thus constitute an alternative way for water-footprint standards to be considered compatible with WTO law.

Initially the discussions on ppm-related distinctions were focused on the MFN principle which, as mentioned, prevents WTO members to discriminate among the 'like products' originating from other WTO member States with regard to import/export regulations, taxes, customs duties and any charges of the like. If a member State would grant a concession in this regard to another member State (the most favoured nation), than the former is automatically obliged to grant the same concession, immediately and unconditionally, to all other member States.

Probably the first case dealing with ppm within GATT obligations was the case *Spain – unroasted coffee* [94], which concerned a product related ppm, namely the way unroasted coffee beans were produced. The litigation was brought by Brazil before a GATT panel for an administrative measure distinguishing the tax treatment of three different types of unroasted coffee (in particular, the three sub-categories identified in the measure were mild, unwashed Arabica and Robusta unroasted coffee). Spain considered that the new sub-classification of unroasted coffee was justified by a number of differences during cultivation and processing, which led to different flavours of the end-products and thus to differences in consumer's tastes. Brazil complained before the panel claiming an article I GATT violation, arguing that Spain's different taxation of varieties of unroasted coffee was illegal under article I GATT, and that all unroasted coffee beans should be considered as 'like products'. The panel found that Spain could not refer to a difference in cultivation and/or processing methods in order to consider the same physical product (unroasted coffee beans) as 'unlike products' for GATT purposes.

The panel investigated upon differences in 'cultivation methods' and 'the genetic factor' as criteria to distinguish between otherwise like products, and it then rejected 'cultivation methods' as a criterion to distinguish the tax treatment of like products. For what of our interest, water-related ppms, as non-product related ppms, do not physically differentiate products, thus one can imagine that the panel would have rejected those as well.

The discussion on ppm then shifted under provisions laid down by article III of the GATT, the 'national treatment' provision. Under the national treatment principle, 'like' national and foreign

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[90] Temmerman, F. (2011), Virtual water trade and international trade law, NCCR Working Paper No. 2011/15.

[91] Marrakesh Agreement Establishing the World Trade Organization – its preamble states "(t)he Parties to this Agreement Recognizing that their relations in the field of trade and economic endeavour should be conducted with a view to raising standards of living, ensuring full employment and a large and steadily growing volume of real income and effective demand, and expanding the production of and trade in goods and services, while allowing for the optimal use of the world's resources in accordance with the objective of sustainable development, seeking both to protect and preserve the environment and to enhance the means for doing so in a manner consistent with their respective needs and concerns at different levels of economic development (…)".

[92] Article XX (b) GATT.

[93] Article XX (g) GATT.

[94] See *Spain – Tariff Treatment of Unroasted Coffee*, Report of the Panel, 11 June 1981.

products should not be treated in a discriminatory manner; therefore, if a non-product related ppm distinction for 'like' products would not be accepted, than a different taxation for foreign products as compared to national products, according to the amount of water which has been used to produce them, would violate article III GATT.

The first case to discuss ppm within the context of the national treatment principle is the *US – Tuna/Dolphin* case[95]: this was the first time that an environmental standard was accused of violating the GATT non-discrimination principle. At the origin of the dispute lied a 1972 US regulation[96] aiming at the protection of dolphins which were collateral victims to tuna-fishing with large nets in the Eastern Tropical Pacific Ocean. In the year 1990, after a court decision, the US imposed their regulation also upon imported tuna, installing an embargo against imported tuna which was caught while exceeding by more than 25% the US maximum allowable amount of dolphins' collateral losses. Mexico, suddenly losing market share in the US, brought the dispute before the GATT panel. US invoked article XX GATT's exceptions (article XX(b) and article XX(g)).

The panel concluded that these provisions didn't allow for the extra-jurisdictional imposition of national (environmental) regulation upon other member States. It first considered that if the broad interpretation of article XX(b) suggested by the United States were accepted, each contracting party could unilaterally determine the life or health protection policies from which other contracting parties could not deviate without jeopardizing their rights under the General Agreement. The General Agreement would then no longer constitute a multilateral framework for trade among all contracting parties but would provide legal security only in respect of trade between a limited number of contracting parties with identical internal regulations.

The panel further noted that article XX(g) allows each contracting party to adopt its own conservation policies. However, the panel considered that if the extra jurisdictional interpretation of article XX(g) suggested by the United States were accepted, each contracting party could unilaterally determine the conservation policies from which other contracting parties could not deviate without jeopardizing their rights under the General Agreement. Thus, the same considerations that led the panel to reject an extra jurisdictional application of article XX(b) were applied also to article XX(g).

The panel's decision to refuse the extra-jurisdictional application of an environmental standard under article XX (b) and (g) GATT provoked wide-spread outrage amongst environmental protectionists (to the extent of severely undermining WTO's legitimacy in the public debate), and is still heavily criticized by legal scholars[97]. Unlike later article XX GATT cases, the panel inquiry didn't even reach article XX's 'chapeau' level[98]. If we would extrapolate the panel's judgment of the *US - Tuna / Dolphin* case to the issue of water-related ppms, this would then most likely mean a ban on any extra-jurisdictional imposition of a national water footprint regulation under article XX (b) and (g) GATT. However, although this cases reflects the line of thinking of the panel at that time, the ruling was not formally adopted and thus remained legally non- binding.

Another case which could be of particular interest in the case of water-related ppms is the case *US – Alcoholic and Malt Beverages* [99], where the panel elaborated its views on the 'like products' discussion under article III GATT. At stake was (among a variety of other issues) a tax reduction granted by the state of Mississippi for wine produced with a certain type of grapes. The grapes variety in question was

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[95] See *United States - Restrictions on Imports of Tuna*, Report of the Panel, 3 September 1991.

[96] 1972 Marine Mammal Protection Act (MMPA).

[97] Charnovitz, S. (2002), The Law of Environmental "PPMs" in the WTO: Debunking the Myth of Illegality, Yale Journal of International Law (YJIL), 27(1).

[98] In fact, article XX GATT establishes a right to adopt measures for specific purposes that is subject to specific conditions set out in the subparagraphs of Article XX and to the horizontal conditions set out in the Chapeau. While the conditions laid down in article XX's subparagraphs are focused on the trade restrictive effects of member States' measures, the horizontal conditions laid down in article XX 'chapeau' are focused on two different aspects of the measures. One condition is focused on the discriminatory effects of these measures, which can be justified, and which in practice result from the non-application of the restrictive effects of these measures (these restrictive effects being justified under the subparagraphs) to competitive products from other origins. The second condition is focused on any protectionist purpose of these measures that is 'disguised' by a legitimate purpose, and this cannot be justified. For a comprehensive discussion, please refer to Bartels, L., (2014), The Chapeau of Article XX GATT: A New Interpretation. University of Cambridge Faculty of Law Research Paper No. 40/2014.

[99] See *United States - Measures Affecting Alcoholic and Malt Beverages*, Report of the Panel, 19 June 1992.

only cultivated in the South-East of the United States and the Mediterranean area. Canada complained that this tax reduction didn't apply to their exported wines. The panel first established that referring to the use of a particular type of grape, which only grew in the South-East of the United States and in the Mediterranean region, in order to make a distinction between wines as otherwise 'like products', effectively meant to take a geographical distinction as a criterion to differentiate between otherwise like products. The panel then argued that such 'de facto' geographical distinction for 'like products' had the effect 'as to afford protection' to this specific geographical area, which is prohibited by article III GATT. Additionally, the panel emphasized that, even in the case that wine from this particular grape would considered to be unlike other wine, these products would still be 'directly competitive' and thus they would still need to be considered as like products for GATT purposes.

What are the likely implications of this panel's ruling for what concerns water-related ppms? Preliminary, it has to be observed a similarity between a water-footprint distinction and a geographical distinction. How would then a water-footprint standard have been considered by that panel, a manner 'so as to afford' protection to these geographical areas, or would the alleged goal of global water saving prevail as to legitimize the government's policy? From the reasoning of the panel, one should come to conclusion that the likely outcome would be in favour of the former.

This strict approach taken by the GATT panel in the early case-law above described was not followed in the case *US – Taxes on Automobiles* [100], where the panel departed from previous case-law and actively sought a compromise to accommodate the needs of governments to legitimately consider non-trade concerns under article III GATT, without affecting the panel's ability to tackle protectionist measures.

In fact, the panel developed a novel interpretation of the phrase 'so as to afford protection' out of article III GATT, whose outcome was a two-tiered test, now known as the 'aim and effects test'[101]:

"5.10 (a) measure could be said to have the aim of affording protection if an analysis of the circumstances in which it was adopted, in particular an analysis of the instruments available to the contracting party to achieve the declared domestic policy goal, demonstrated that a change in competitive opportunities in favour of domestic products was a desired outcome and not merely an incidental consequence of the pursuit of a legitimate policy goal. A measure could be said to have the effect of affording protection to domestic production if it accorded greater competitive opportunities to domestic products than to imported products."

What would this test imply for water-related ppms? The alleged goal of global water saving as an environmental criterion could maybe prevail, especially whether the international community would make it a common, global, goal. However, this panel ruling was never adopted, and the 'aims and effects test' was heavily criticized by following panel and Appellate Body rulings. As a result, the attention in cases of dispute settlement reviews of non-trade (environmental) concerns under GATT/WTO law moved to the general exceptions under article XX GATT.

The *EC – Asbestos* case[102] concerned a French regulation banning production and trade of asbestos fibres and products containing such fibres[103]. Canada, having an important asbestos industry, filed a WTO complaint claiming incompatibility of the French decree with article III GATT. The Panel decided that the measure at stake was indeed not permissible under article III GATT, though acceptable as a 'human health' related exception under article XX (b) GATT. The Appellate Body upheld the Panel's findings regarding article XX (b), but reversed the Panel's judgment regarding article III GATT. The Appellate Body stated that a health criterion could very well be a valid criterion in order to distinguish between otherwise 'like products' for the purposes of article III GATT; not as a 'separate'

[100] See *United States – Taxes on Automobiles*, Report of the Panel, 11 October 1994.

[101] Cottier, T. and Oesch, M. (ed.), (2005), International Trade Regulation, Law and Policy in the WTO, the European Union and Switzerland, Bern, Switzerland/London, UK, Staempfli Publishers/Cameron May, p. 404.

[102] See *European Communities – Measures Affecting Asbestos and Products Containing Asbestos*, Appellate Body Report, (WT/DS135/AB/R), 12 March 2001.

[103] Décret no. 96-1133 relatif à l'interdiction de l'amiante, pris en application du code de travail et du code de la consummation (24 December 1996, entered into force 1 January 1997).

criterion but embedded in the Border Tax Adjustment criteria[104]:

"113. The European Communities argues that the inquiry into the physical properties of products must include a consideration of the risks posed by the product to human health. In examining the physical properties of the product at issue in this dispute, the Panel found that "it was not appropriate to apply the 'risk' criterion proposed by the EC". The Panel said that to do so "would largely nullify the effect of Article XX(b)" of the GATT 1994. In reviewing this finding by the Panel, we note that neither the text of Article III:4 nor the practice of panels and the Appellate Body suggest that any evidence should be excluded a priori from a panel's examination of "likeness". Moreover, as we have said, in examining the "likeness" of products, panels must evaluate all of the relevant evidence. We are very much of the view that evidence relating to the health risks associated with a product may be pertinent in an examination of "likeness" under Article III:4 of the GATT 1994. We do not, however, consider that the evidence relating to the health risks associated with chrysotile asbestos fibres need be examined under a separate criterion, because we believe that this evidence can be evaluated under the existing criteria of physical properties, and of consumers' tastes and habits, to which we will come below."

One could think that if a health criterion would be an acceptable basis for discrimination, then also an environmental criterion, such as a water footprint standard, could also pass this test. This consideration could be reinforced in the light of two additional cases adjudicated by the WTO in the context of non-product related ppms.

In the first one, *US – Reformulated Gasoline*, at stake was an implementing regulation of the US Clean Air Act, 'the Gasoline Rule', aimed at reducing pollution caused by gasoline combustion in the US, and imposing stringent requirements to the composition of gasoline. However, different standards were applied for domestic and imported gasoline. Venezuela and Brazil brought this measure before a WTO panel. The panel, after having found that the Gasoline Rule breached the article III national treatment provisions, stated that the Gasoline Rule fell outside of the scope of the article XX (b), (d) and (g) exceptions. But the US appealed, and the Appellate Body, for the first time, found an environmental ppm to be justified under article XX (g)[105]. However, the Appellate Body found the requirements of article XX's Chapeau to be breached. The Appellate Body first addressed the question whether the Gasoline Rule relates 'to the conservation of an exhaustible resource', and found that Article XX(g) and its phrase, 'relating to the conservation of exhaustible natural resources', need to be read in context and in such a manner as to give effect to the purposes and objects of the General Agreement, and with reference to the second part of article XX (g) on the question whether 'such measures are made affective in conjunction with restrictions on domestic production or consumption', the Appellate Body found it to be a requirement that the measures concerned impose restrictions, not just in respect of imported gasoline but also with respect to domestic gasoline. The clause is a requirement of even-handedness in the imposition of restrictions, in the name of conservation, upon the production or consumption of exhaustible natural resources. For the judges, if no restrictions on domestically-produced like products are imposed at all, and all limitations are placed upon imported products alone, the measure cannot be accepted as primarily designed for implementing conservationist goals. The measure would simply be disguised discrimination for protecting domestic production.

The Appellate Body then turned on the question whether clean air could be considered an exhaustible natural resource, and it confirmed the positive finding of the panel in this regard. Therefore, it may be argued that fresh water too, if a dispute would arise, could be effectively considered as an 'exhaustible resource' in the meaning of article XX (g) GATT, as clean air was.

In a later case, the *US - Shrimp/ Turtle* case[106], at stake was a US measure aimed at protecting endangered sea turtles from incidental catch during the fishing of shrimp. US imposed an import ban on shrimp which was harvested with technology 'adversely affecting' endangered sea turtles. Other than that, an exporting country could also be annually certificated as having a comparable program for the

[104] See *EC – Asbestos*, Appellate Body Report, para 128 and para. 142.

[105] See *US – Standards for Reformulated and Conventional Gasoline*, Appellate Body Report, (WT/DS2/AB/R), 29 April 1996, para. 29.

[106] See *United States – Import Prohibitions of Certain Shrimp and Shrimp Products*, Report of the Panel, (WT/DS58/R), 15 May 1998.

protection of sea turtles and a similar incidental catch rate. In order to assess the latter, guidelines were issued regularly. The 1996 guidelines extended jurisdiction to all shrimp harvesting nations. A couple of years before, US shrimp vessels were obliged to fish with Turtle friendly TEDs or work with a 90 minutes tow-time limitation in sea turtle areas in order to reduce the incidental drowning of sea turtles.

Jointly, four countries complained before the WTO against this discrimination (India, Malaysia, Pakistan and Thailand). The US claimed that its regulation and implementing guidelines were justified under article XX (g) and (b) GATT. The panel first ruled against the US in an article XX 'chapeau down' approach concluding that the measure at stake fell outside the scope of the chapeau. The panel ruling was severely criticized by the Appellate Body which in turn installed a three staged bottom-up assessment under article XX (g) GATT. Although the Appellate Body in the end equally concluded, after having found that the measures at stake were preliminary justified under article XX (g), that the requirements of the chapeau were not met, some important statements regarding the assessment of environmental measures under article XX GATT were made. In fact, the Appellate Body made a complete U-turn as compared to the findings of the (non-adopted) *US - Tuna/ Dolphin* case.

The Appellate Body pointed out that the principle of sustainable development is formally an additional objective under WTO law:

"153. We note once more that this language demonstrates a recognition by WTO negotiators that optimal use of the world's resources should be made in accordance with the objective of sustainable development. As this preambular language reflects the intentions of negotiators of the WTO Agreement, we believe it must add colour, texture and shading to our interpretation of the Agreements annexed to the WTO Agreement, in this case, the GATT 1994. We have already observed that Article XX(g) of the GATT 1994 is appropriately read with the perspective embodied in the above preamble."

Then the Appellate Body elaborated the theoretical framework of examination under article XX's chapeau as the nevralgic centre where equilibrium between legitimate trade objectives and legitimate environmental concerns should be found:

"158. The chapeau of Article XX is, in fact, but one expression of the principle of good faith. This principle, at once a general principle of law and a general principle of international law, controls the exercise of rights by states. One application of this general principle, the application widely known as the doctrine of abus de droit, prohibits the abusive exercise of a state's rights and enjoins that whenever the assertion of a right "impinges on the field covered by [a] treaty obligation, it must be exercised bona fide, that is to say, reasonably." An abusive exercise by a Member of its own treaty right thus results in a breach of the treaty rights of the other Members and, as well, a violation of the treaty obligation of the Member so acting. Having said this, our task here is to interpret the language of the chapeau, seeking additional interpretative guidance, as appropriate, from the general principles of international law.

159. The task of interpreting and applying the chapeau is, hence, essentially the delicate one of locating and marking out a line of equilibrium between the right of a Member to invoke an exception under Article XX and the rights of the other Members under varying substantive provisions (e.g., Article XI) of the GATT 1994, so that neither of the competing rights will cancel out the other and thereby distort and nullify or impair the balance of rights and obligations constructed by the Members themselves in that agreement. The location of the line of equilibrium, as expressed in the chapeau, is not fixed and unchanging; the line moves as the kind and the shape of the measures at stake vary and as the facts making up specific cases differ."

The Appellate Body came to the conclusion that the measure at stake did constitute an 'unjustifiable and arbitrary discrimination' towards other Member States, in the sense of article XX's chapeau. Additionally, the Appellate Body made the effort to clarify the consequences of its ruling under article XX GATT with regard to environmental concerns in general:

"185. In reaching these conclusions, we wish to underscore what we have not decided in this appeal. We have not decided that the protection and preservation of the environment is of no significance to the Members of the WTO. Clearly, it is. We have not decided that the sovereign nations that are Members of the WTO cannot adopt effective measures to protect endangered species, such as sea turtles. Clearly, they can and should. And we have not decided that sovereign states should not act together bilaterally, plurilaterally or multilaterally, either within the WTO or in other international fora, to protect endangered species or to otherwise protect the environment. Clearly, they should and do.

186. What we have decided in this appeal is simply this: although the measure of the United States in dispute in this appeal serves an environmental objective that is recognized as legitimate under paragraph (g) of Article XX of the GATT 1994, this measure has been applied by the United States in a manner which constitutes arbitrary and unjustifiable discrimination between Members of the WTO, contrary to the requirements of the chapeau of Article XX. For all of the specific reasons outlined in this Report, this measure does not qualify for the exemption that Article XX of the GATT 1994 affords to measures which serve certain recognized, legitimate environmental purposes but which, at the same time, are not applied in a manner that constitutes a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail or a disguised restriction on international trade. As we emphasized in United States – Gasoline, WTO Members are free to adopt their own policies aimed at protecting the environment as long as, in so doing, they fulfill their obligations and respect the rights of other Members under the WTO Agreement."

The bilateral and multilateral negotiating efforts conducted by the US before introducing the measure at stake, was a crucial criterion in the Appellate Body's assessment. The Appellate Body ultimately found that the US had not done everything necessary in this regard, in order satisfy the chapeau's requirements.

"122. We concluded in United States – Shrimp that, to avoid "arbitrary or unjustifiable discrimination", the United States had to provide all exporting countries "similar opportunities to negotiate" an international Agreement. Given the specific mandate contained in Section 609, and given the decided preference for multilateral approaches voiced by WTO Members and others in the international community in various international Agreements for the protection and conservation of endangered sea turtles that were cited in our previous Report, the United States, in our view, would be expected to make good faith efforts to reach international Agreements that are comparable from one forum of negotiation to the other. The negotiations need not be identical. Indeed, no two negotiations can ever be identical, or lead to identical results. Yet the negotiations must be comparable in the sense that comparable efforts are made, comparable resources are invested, and comparable energies are devoted to securing an international Agreement. So long as such comparable efforts are made, it is more likely that "arbitrary or unjustifiable discrimination" will be avoided between countries where an importing Member concludes an Agreement with one group of countries, but fails to do so with another group of countries.

Thus, according to the *US - Shrimp/ Turtle* case-law, before issuing any unilateral measure with global impact, it would be necessary for WTO member countries to make negotiating efforts in good faith, while giving all trading partners involved equal treatment. Clearly, such a conclusion has far-reaching consequences for any 'ppm-distinction' in the 'like products' debate. Any unilateral action in this field, such as the introduction of water-footprint standards to stimulate global water savings, could only be an option after having initiated and conducted thorough international negotiations with all trading partners alike.

2.3.2 WTO compatibility of water-footprint labelling schemes

The necessary basis for well-informed governmental policy as well as consumer action is product transparency; this requires that all relevant information about a product is publicly available. Understandably, labels give consumers especially valuable information when they relate to attributes not immediately apparent in the final product.

Water labeling would give consumers information about the water footprint of a given product; it would offer one approach to inducing more efficient use of water and to limiting unsustainable exploitation of water resources. Water labeling in the context of trade in virtual water would potentially make water content a factor in demand for certain products. Consumers can draw on environmental, social, and other values in making purchasing decisions, and put pressure on producers to conform to these values[107].

When referring to products' water footprint, relevant information may include information and data on how much water was consumed to make the product during its entire production cycle; how much water was polluted as a consequence of its production processes and what type of water was polluted; whether the water consumed could have been used for an alternative purpose with a higher societal benefit, etc.. In fact, products may often look alike – in terms of colors, taste, etc. – but nevertheless they may be quite different. As an example, the crop may be grown with irrigation water from the overexploited basins in some water-poor regions or under rain-fed conditions in a different water-rich region[108].

Governments could therefore think of raising trade barriers against products that are considered unsustainable, or responsible for harmful effects on water resources of arid regions. Governments could effectively achieve such objectives only when proper arrangements for product transparency are in place.

Thus, the necessity of product transparency could be translated into a water label. This term should be understood in very broad terms, because it could be a label physically attached to a product, but also digital information about a specific product available through internet by scanning its barcode in the shop or at home. Furthermore, it could be a simple label showing whether a product meets a certain set of sustainability criteria (a yes or no label), but it could also be a more advanced label with detailed quantitative information on a number of relevant criteria. Introducing such a label would be most relevant for water-intensive products, i.e. products that are usually related to large volumes of water consumption and/or pollution[109].

Within this context, the experience already matured with regard to environmental labels can represent a useful benchmark. Environmental labels have been effective in enabling consumers pressure to manage producer behaviour. For example, rising public concerns about dolphin-killing in the late 1980s led USA and other countries to create 'dolphin-safe' tuna labels, to allow consumers to purchase according to their values, sending a price signal to producers and ultimately leading to a change in typical sourcing practices for canned tuna. However, labeling standards impose a cost on producers, which can be problematic for smaller producers and developing countries producers[110].

Little has been written about the trade implications of virtual water labels; it is unclear yet how current WTO rules would play in case of a dispute brought before the WTO Dispute Settlement Body. However, some useful lessons can be drawn from previous case-law concerning environmental labels.

Consider the case in which a country raises a trade barrier for all countries that do not fulfill the requirements of the water-labeling scheme. Given the decisions made in earlier disputes previously discussed, the WTO rules are unlikely to lead to acceptance of discrimination of products from countries not fulfilling a certain labeling requirement if those countries have not signed up for that labeling scheme. As recalled in the previous section, the WTO judges explicitly stated that one country cannot impose its own environmental regulations on another country[111].

Both government and private water labeling schemes potentially raise questions under the WTO

[107] Weiss, E.B., and Slobodian, L., (2014), Virtual Water, Water Scarcity, and International Trade Law, Journal of International Economic Law, 17, 717-737.

[108] Hoekstra, A. Y., (2010), The relation between international trade and freshwater scarcity, WTO Staff Working paper ERSD-2010-05, January 2010.

[109] Hoekstra, A. Y., (2010), The relation between international trade and freshwater scarcity, WTO Staff Working paper ERSD-2010-05, January 2010.

[110] Kloeckner, J., (2012) The power of eco-labels: communicating climate change using carbon footprint labels consistent with international trade regimes under the WTP, 3 Climate Law, 209-230.

[111] Charnovitz, S. (2002), The Law of Environmental "PPMs" in the WTO: Debunking the Myth of Illegality, Yale Journal of International Law (YJIL) 27.

legal system. The issues depend on the standardizing body, the nature of regulation or requirements, and the type of labeling system used[112].

Government regulations which promulgate or facilitate labeling standards raise some of the same issues as direct regulation of virtual water content under the TBT Agreement and the GATT Agreement. The type of issue depends on the nature of the labeling regulation, whether it is voluntary or compulsory, and what type of labeling system it employs.

Under the TBT Agreement, for a measure to be considered a 'technical regulation', compliance must be mandatory. However, even voluntary labels could be considered mandatory if their use is a pre-requisite to entry a market. For example, in US-Tuna II[113] the Appellate Body found that US provisions on 'dolphin-safe' labeling for canned tuna were inconsistent with article 2.1 of the TBT Agreement. It found that these labels could be characterized as technical regulations because, although producers could sell products without the label, they could not use any other label containing terms related to dolphins, which limited their ability to compete in an environmentally conscious market.

Like direct regulations of virtual water content, government labeling regulations must not treat imported products less favorably than domestic products or products originating in other third countries: in short, these labeling schemes should apply the same requirements to all like products, regardless of their country of origin and the production method utilized. Thus, if producers from a certain country were disproportionately unable to meet water efficiency standards, those countries could claim de facto discrimination under the TBT Agreement or the GATT Agreement. As for the GATT Agreement's provisions discussed before, a finding of de facto discrimination only indicates a violation under the TBT if the detrimental impact does not derive from a legitimate regulatory distinction. In the US- Tuna II case, the Appellate Body found that the de facto discrimination constituted treatment less favourable because USA employed different labeling requirements for tuna caught within the Eastern Tropical Pacific region as opposed to tuna caught outside of that region, and this distinction was not fine-tuned with the effective risks of dolphins being caught with the different fishing methods adopted in the different regions[114].

Private virtual water labeling schemes would not be directly subject to WTO trade rules unless officially adopted by a national government. However, governments also have obligations to "supervise" private standards under the TBT Agreement article 4, by which they are obliged to take reasonable measures to ensure that non-governmental standardizing bodies within their territory act in compliance with the requirements contained in the Agreement's Code of Good Practice, establishing that standards should not be applied with a view to creating unnecessary obstacles to international trade.

Therefore, one can conclude that there is still much ambiguity about the role that national environmental standards and labeling schemes related to processes and production methods can play with concern to trade in virtual water. Of course, doubts would disappear in the case where a (multilateral) international agreement on water-footprint standards would be achieved and participated by the majority of the global community. In the absence of such a multilateral agreement, previous WTO case-law may well prevent countries from enforcing national water-footprint standards to imported products.

2.3.3 Water-related subsidies and their compatibility with WTO law

A major issue when talking about sustainable water governance and international trade is the fact that the international market for agricultural products is heavily distorted by production subsidies and water subsidies alike. In fact, currently, water inputs do not form a substantial component of the

[112] Weiss, E.B., and Slobodian, L., (2014), Virtual Water, Water Scarcity, and International Trade Law, Journal of International Economic Law, 17, 717-737.

[113] See *United States – Measures concerning the importation, marketing and sale of tuna and tuna products*, Appellate Body Report, (WT/DS381/AB/R), 13 June 2012.

[114] Weiss, E.B., and Slobodian, L., (2014), Virtual Water, Water Scarcity, and International Trade Law, Journal of International Economic Law, 17, 717-737.

total price of even the most water-intensive products. This is a crucial element, up to the point that many authors argue that the priority to achieve global water efficiency is to arrive at a global agreement on water pricing structures that would cover the full cost of water use, including investment costs, operational and maintenance costs, a water scarcity rent and the cost of negative externalities of water use[115]. Without an international treaty on proper water pricing it is unlikely that a globally efficient pattern of water use will ever be achieved.

Governments of both developed and developing countries heavily subsidize water supply, for example through investments in infrastructure like dams and canals or for water distribution, with the users generally not paying for the associated costs.

Irrigated agriculture consumes about 65% of all fresh-water resources in developed countries, and up to 90% in certain developing countries[116]. Thus, the debate on agricultural subsidies and water focuses on irrigation subsidies, which are a form of domestic support. Irrigation subsidies may play a significant role in inefficient water resources' management and overuse, preventing scarcity factors to influence virtual water trade, thus exacerbating water scarcity problems of specific countries or regions.

The mandate of the Doha round of trade negotiations include reducing trade-distorting agricultural subsidies. It may be expected that the phasing-out of the agricultural subsidies will increase the price of the products on the international market. Studies have found different results as to the extent of such prices' increase: some authors found a significant increase in the price of agricultural products such as cereals and meat products by removing subsidies and trade barriers[117], whereas other studies focused on irrigated agricultural products estimated a small increase of the prices of these products[118].

Public interest in the issue of irrigation water pricing has increased worldwide in recent years, with increasing awareness of water scarcity problems and distorted incentives granted, as well as with a growing appreciation of the opportunity costs of allocating water among competing uses. Many of the world's large-scale irrigation projects were constructed and placed in service in an era when water was relatively abundant or when the cost of developing water supplies in arid regions seemed a reasonable expense for expanding agricultural production and generating economic growth. Over the years, the incremental costs and benefits of irrigation have changed, as have public preferences regarding the allocation of water among agricultural, municipal, and environmental uses. With increasing scarcity, the opportunity cost of choosing one use over another increases as well[119]. However, it is also necessary to acknowledge that irrigation subsidies have contributed so far to low food prices, and they have also enhanced economic development in many developing countries.

Subsidies for water irrigation are discussed in this paper in the context of international trade; in fact, many water problems are closely linked to international trade. Current examples include subsidized water in Uzbekistan being overused to produce cotton for export and the depletion of water resources in Kenya for flowers' production destined to the European markets[120], as well as overuse problems in Thailand for the production of rice and in Brazil for the export of fruits[121].

Both export subsidies and domestic production subsidies can play a driving role in the trade of virtual water, by lowering global prices of agricultural products even below the cost of production. Developed countries are primary users of such subsidies.

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[115] Abu-Zeid, M. (2001), Water Pricing in Irrigated Agriculture, International Journal of Water Resources Development 17(4); Hoekstra, A. Y., (2010), The relation between international trade and freshwater scarcity, WTO Staff Working paper ERSD-2010-05, January 2010.

[116] Abu-Zeid, M., (2001), Water Pricing in Irrigated agriculture, International Journal of Water Resources Development 17(4).

[117] Ramirez-Vallejo, J. and Rogers, P., (2004), Virtual Water Flows and Trade Liberalization, Water Science and Technology 49, 25-32.

[118] Cornish, G.A., and Fernandez, S., (2005), Agricultural Trade Liberalization: Implications for Irrigated Agriculture, IPTRID Issue Paper no.5/2005, FAO.

[119] OECD, (2010), Agricultural Water Pricing: United States, OECD, Paris.

[120] Hoekstra, A. Y., (2010), The relation between international trade and freshwater scarcity, WTO Staff Working paper ERSD-2010-05, January 2010.

[121] World Trade Organization, (2010), World Trade Report 2010: Trade in natural resources (Switzerland: WTO, 2010).

2.3.3.1 Defining irrigation subsidies

Irrigation subsidies are mostly granted with the purpose of facilitating the pumping of groundwater or surface water[122].

Irrigation subsidies are a form of domestic support; they may play a significant role in inefficient water resources' management and overuse, preventing scarcity factors to influence virtual water trade, thus exacerbating water scarcity problems of specific countries or regions.

Irrigation subsidies can generate a competitive advantage for farmers in one country, if farmers in another country are required to pay a (higher) water price reflecting a greater range of cost elements, including for example scarcity rent or its opportunity costs. Farmers will have a greater incentive to irrigate efficiently and choose higher valued crops if water price embodies its full costs as well as the opportunity costs of using water in other sectors.

There is a lack of reliable statistics on the amount of irrigation subsidies in most countries, including the most advanced ones. Some reports estimate the total amount of irrigation subsidies provided at the European Union level at 1.2 billion Euros annually in the late '90s and for the USA at 7.4 billion dollars annually on average in the early 2000's[123]. Irrigation subsidies are massively provided also in developing countries and in water-poor countries as well.

As reported by the OECD[124], an economists' view would call for the elimination of irrigation subsidies, since water is a commodity and should be priced accordingly. Opposing views suggest that subsidies can be justified because irrigation projects provide both public and private goods, or because higher water prices will reduce agricultural net revenues without motivating notable reductions in irrigation diversions, especially when taking into account the low elasticity of demand for irrigation water observed in many settings. When demand is price inelastic, quantity demanded declines by a smaller proportion than an increase in price, such that revenues collected from water users increase substantially, with little change in the volume of irrigation water used.

However, it seems that an important difference can be pointed out among irrigation subsidies depending on the water-endowment of the subsidizing country and the type of agricultural products being subsidized.

In all those cases where irrigation subsidies are granted to agricultural production of water-intensive products in water-deficit countries, a distorting incentive towards the production of water-intensive agricultural products is provided. This incentive is, in fact, distorting for the trade of third countries with respect to the water-intensive products whose production is being subsidized; moreover, this increases the environmental costs for the non-efficient use of the scarce resource (water). These costs have to be summed up to the costs of the subsidies for the subsidizing country.

Differently, when irrigation subsidies are provided in water-rich countries, for the production of water-intensive products, those subsidies could even be environmentally beneficial, as water-rich regions would have incentive for the production of more water-intensive crops, whereas little distortion of trade would be created for low water-demanding crops production in water-scarce regions.

2.3.3.2 Irrigation subsidies and WTO-covered Agreements

Generally speaking, under the WTO system, both the Agreement on Agriculture (AG)[125] and the Agreement on Subsidies and Countervailing Measures (ASCM)[126] regulate agricultural subsidies that distort trade, including export subsidies and domestic support subsidies.

The ASCM regulate the use of subsidies and countervailing duties, which are applied to imports

[122] Yang, H., and Wang, L., (2006), Virtual water trade: an assessment of water use efficiency in the international food trade, Hydrology and Earth System Sciences (HESS) 10(3): 443-454.

[123] Berthelot, J. (2006), Review of the EU Agricultural distorting supports to rebuild fair and sustainable Agricultural trade rules after the Doha Round hibernation.

[124] OECD, (2010), Agricultural Water Pricing: United States, OECD, Paris.

[125] WTO Agreement on Agriculture, 1994.

[126] WTO Agreement on Subsidies and Countervailing Measures, 1994.

to offset injury to domestic industry caused by the subsidized imports. The ASCM can be considered as the general agreement within the WTO legal system which applies horizontally to all types of subsidies. Domestic support subsidies are actionable under the ASCM only if they are specific to a particular enterprise or region and if they cause adverse effects to the domestic interests of another member country.

Article 1.1 of the ASCM constitutes an international legal standard of what constitutes a subsidy for the purposes of the WTO-covered agreements' interpretation and application. The definition of a subsidy under article 1 ASCM is often criticized as being loose, providing room for interpretations and leaving certain implicit subsidies uncovered. Furthermore, the ASCM exempts subsidies for the construction of 'general infrastructure' and it requires injury to a domestic industry of the importing country. Therefore, some authors argue that such market distortion may be difficult to show in the case of water-related subsidies, and that it may also be difficult to show that water-related subsidies meet the definition and specificity requirements for actionable subsidies under the ASCM[127].

More specific rules concerning agricultural subsidies are laid down in the AG. The AG is 'lex specialis' to the ASCM and covers three main topics related to agricultural products: domestic support, market access and export subsidies. Annex 1 of the AG lists the products covered by this agreement by referring to their customs classification (WCO's HS - Harmonized system of classification). The AG limits the aggregate amount of domestic support that each member country can provide that falls into the category of support deemed to have the greatest impact on trade ('amber box'). This is subject to certain exemptions, the so-called 'green' and 'blue' boxes. Provisions on reducing agricultural domestic support under the AG are called 'disciplines'. All trade-distorting agricultural subsidies fall under the so-called 'amber-box' and are subject to reductions as laid down in Member's schedules.

Reduction commitments are expressed in so-called 'total AMS'[128] whose calculation is product-specific and traced out in annexes three and four of the AG[129]. As a general rule, developed countries are bound to higher reduction commitments and they need to respect a shorter implementation period then developing countries, while least developed countries receive special and differential treatment combined with a longer implementation period.

Non-trade distorting subsidies, to be notified under a 'green'[130] or a 'blue'[131] box, are not subject to reductions and can even be increased.

An important difference has to be highlighted here, which has consequences on the legal status of irrigation subsidies under the AG Agreement.

In all those cases where irrigation subsidies are granted to agricultural production of water-intensive products in water-deficit countries, a distorting incentive towards the production of water-intensive agricultural products is provided. This incentive is, in fact, distorting for the trade of third countries with respect to these water-intensive products. These trade distorting subsidies, as such, are potentially liable to WTO sanctions under the AG provisions. Furthermore, these irrigation subsidies do not seem to qualify for article XX GATT exceptions, providing for relief from trade sanctions for those governments' measures aimed at the achievement of environmental, public health or safety objectives.

Differently, even if the trade distortion impact remains, irrigation subsidies in water-rich countries for the agricultural production of water-intensive products could be environmentally-beneficial, and thus potentially qualify under article XX GATT exceptions.

This conclusion should however be seen in the general context of current trade negotiations in the area of agricultural products being conducted among WTO members as part of the Doha Round of

[127] Weiss, E. B., Boisson de Chazournes, L., and Bernasconi–Osterwalder, N., (2009), Fresh Water and International Economic Law New York, USA, Oxford University Press: 207-235; Weiss, E.B., and Slobodian, L., (2014), Virtual Water, Water Scarcity, and International Trade Law, Journal of International Economic Law, 17, 717-737.

[128] Total Aggregate Measurement of Support.

[129] There is a *de-minimis* threshold before the calculation of total AMS reduction.

[130] Domestic support listed under the so-called 'green-box' is considered to be non- or minimally trade distorting and is not subject to reduction.

[131] Domestic support listed under the so-called 'blue-box' is not subject to reduction if the total production of the concerned product is reduced.

Negotiations.

In fact, developed countries such as the USA and the EU continue to refuse to modify their respective protectionist approach for food and agricultural products, which seems to have been the main stumbling block for a positive end of the Doha negotiations many times over the last few years. In view of the impact of climate change on water scarcity problems, WTO members should take into account the environmental consequences of irrigation subsidies.

Furthermore, the AG is currently largely ineffective in addressing trade violations for agricultural products and in preventing large amounts of trade distorting domestic support in the agricultural sector. In fact, still now member States are free to choose to list their domestic support to the agricultural sector under a certain category, without any monitoring system being in place and no sanctions established. A further problem for improvements, in fact, lies with the fact that at this moment there are no adequate statistics on irrigation subsidies for the vast majority of countries world-wide. The reporting requirements established for these subsidies under the WTO are not compulsory, thus countries so far have not made available sufficient information on the subsidies domestically provided for water irrigation.

The fact that the AG has, still now, little binding effects for what concerns domestic support in agricultural products is the result - the only possible equilibrium - reached during the previous trade negotiations ended in Marrakesh in 1994 with the institution of the WTO itself, an era which negotiations are widely reported to be de facto lead by developed countries. This is the reason why the AG itself provides for an obligation to continue negotiations on agricultural reforms, whose positive development is not really visible at this moment considering the status quo of the (on-going) Doha negotiations. Such negotiations should contemplate the introduction of an effective monitoring system on irrigation subsidies and other subsidies having an impact on water scarcity, and introduce compulsory notification from member States to the WTO.

2.4 Conclusions

It has been pointed out the existence of a significant imbalance between the strength and sophistication of international environmental agreements compared to international trade agreements. The envisaged consequences of such imbalance include trade rules' obligations likely prevailing over environmental obligations in those cases where a dispute would arise as to the ability of countries to adopt trade measures aimed at protecting scarce water resources. As mentioned, this could be the case of export control measures on water-intensive agricultural products enforced by water scarce countries, or the case of regulatory measures differentiating the treatment of water-intensive imported products based on their water footprint.

Therefore, in the absence of international binding agreements on sustainable water use in the production of goods or services, and in the light of the progressive recognition by the international community of the universal human right of access to (fresh) water and to food during the last fifteen years, it is necessary to reflect on the appropriateness of current trade rules to also address water scarcity issues. For what concerns the topics investigated in this paper, the analysis found that the current WTO legal system is not well suited to address the topic of water-related irrigation subsidies: the discipline on agricultural subsidies is still too loose and with no real teeth, with no serious developments foreseeable within the current round of trade negotiations.

By contrast, for what concerns the opportunity for countries to enforce measures aimed at promoting water-use efficiency, such as water-footprint standards or water-footprint labeling schemes, the WTO seems to have the potential to accommodate such goals, considering its objectives stated in the preamble of the Marrakesh Agreement and the exceptions contemplated for legitimate policies aimed at the protection of health and the environment. However, even if a trend from rejection to efforts for possible compromises can be detected, GATT and WTO case-law did not so far show enough flexibility for promoting non-trade concerns.

It is hoped that WTO judges will show more flexibility in future case-law and, while rejecting protectionist measures, will save domestic measures effectively aimed at the protection of water (and

other scarce environmental resources).

Also, WTO member States, acknowledging WTO as a forum able to play a role for global water-use efficiency, as well as the nature of WTO as a members-driven organization, could claim for themselves the power of closing the gap left open by GATT and WTO judges and panelists. Doing so, they would also greatly contribute to the efforts of legitimizing the WTO before the general public.

APPENDIX 1

Summary of commitments with time-bound targets from international declarations and treaties following the Earth's Summit in Rio (1992)

Declaration / treaty	Target	Delivery Date
Agenda 21		
Protection of water resources, water quality and aquatic ecosystems	All States, according to their capacity and available resources, through bilateral or multilateral cooperation, including the United Nations and other relevant organizations as appropriate, could set the following targets: [...] (e) To reduce the prevalence of water-associated diseases, starting with the eradication of dracunculiasis (guinea worm disease) and onchocerciasis (river blindness) by the year 2000.	2000
Integrated water resources management (IWRM)	(a) By the year 2000: i. To have designed, initiated and targeted national action programs, and to have put in place appropriate institutional structures and legal instruments; ii. To have established efficient water-use programs to attain sustainable resource utilization patterns; (b) By the year 2025: i. To have achieved sub-sectorial targets of all fresh water program areas.	2000 2025
Water resources assessment	(a) By the year 2000, to have studied in detail the feasibility of installing water resources assessment services.	2000
Water and sustainable urban Development	(a) By the year 2000, to have ensured that all urban residents have access to at least 40 litres per capita per day of safe water and that 75 per cent of the urban population are provided with on-site or community facilities for sanitation; (b) By the year 2000, to have established and applied quantitative and qualitative discharge standards for municipal and industrial effluents.	2000
Johannesburg Plan of Implementation		
Access to safe drinking water	The provision of clean drinking water and adequate sanitation is necessary to protect human health and the environment. In this respect, we agree to halve, by the year 2015, the proportion of people who are unable to reach or to afford safe drinking water (as outlined in the Millennium Declaration) and the proportion of people who do not have access to basic sanitation.	2015

IWRM	Develop integrated water resources management and water efficiency plans by 2005, with support to developing countries.	2005
Millennium Declaration (MDG - 7C)		
Access to safe drinking water	Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation.	2015

Chapter 3

The relation between Interstate Conflicts and Virtual Water Trade: A gravity model and networks' approach

3.1 Introduction

The relationship between trade and conflicts has been widely debated in the academic discourse: the theoretical debate is between the "trade promotes peace" liberal school and the neo-Marxist school which argues that asymmetric trade links lead to more conflicts. These two schools depart in the opposing view they have on the possibility of gains from trade for the countries involved; whereas the former asserts that trade integration inhibits the use of force by increasing the opportunity costs of conflicts (Levy, 2003), the latter argues that integration reduces dependence on any one trade partner, thus increasing political autonomy and ultimately encouraging conflict (Martin et al., 2008).

Scholarly research has almost exclusively focused on the relationship between aggregated trade data and conflicts, even though valid theoretical arguments point at possible significant heterogeneity in the impact of different commodities on conflicts (Dorussen 2006).

To this purpose, in this paper we aim at linking the literature on conflicts and trade with the literature on control over scarce resources, by taking into account disaggregated trade in different commodities defined on the basis of the allegedly "strategic" role they play in international relations.

Control over scarce resources has a long history in attracting a great deal of attention in the public debate as well as in the academic literature for its alleged role as a cause of conflicts. In the case of exhaustible mineral resources, such as oil and gas, the role of resources as a trigger for conflicts has been well accepted in the public opinion and in the literature, at least since the "Carter doctrine" was publicly revealed in the mid-70's[132]. Recent examples which the literature pointed out include the invasion of Kuwait by Iraq in 1990, the militarized conflict between Cameroon and Nigeria over the Bakassi peninsula in the early 90's, the Falklands War in the 80's between Argentine and the United Kingdom, as well as a number of contemporary militarized tensions over mineral-rich areas as in the South China Sea[133], or the border between Sudan and South Sudan.[134] It is thus well accepted in the literature the "strategic" role played by oil (and other energy products) in international relations.

Differently, in the case of finite natural (environmental) resources such as water, while political rethoric repeatedly indicated control over water resources as the most likely source for future wars in arid regions[135], the academic literature has not yet systemically addressed such topic, and studies are so far inconclusive as to the causal effect of water scarcity on conflicts.

[132] The "Carter doctrine" states that the US will use all means necessary, including military forces, to fight any attempt to gain control of the Persian Gulf. Furthermore, following the oil shocks in the 1970s, Secretary of State Henry Kissinger told the editors of Business Week that the United States was prepared to go to war over oil and that Washington would have no hesitation to use force "where there's some actual strangulation of the industrialized world" – cited in Acemoglu et al. (2012).

[133] Klare (2001) argues that the South China Sea and the Caspian Basin are the most likely regions to witness large-scale warfare over oil in the future.

[134] See Caselli (2015).

[135] In 1980, then UN Director General Boutros Boutros-Ghali commented with reference to the North Africa - Middle East region that "the next war in our region will be over the waters of the Nile, not politics". On the same line, in 1991, the then Crown Prince of Jordan is reported to have said that the 1967 war "was brought on very largely over water related matters" and that unless there was an interstate water agreement in the Middle East by 2000 "countries in the region will be forced into conflict" (Irani, 1991),

Control over water is necessary intertwined with the topic of food supply. For instance, a key characteristic of the world's poorest and most vulnerable societies is their dependence on rain-fed agriculture for food supply and income (Sachs and Warner, 2000); a recent example include the severe droughts hitting the region of the Horn of Africa that led to a food crisis in a region already heavily affected by civil wars[136]. Therefore, as for oil, one may argue that countries could be willing to enter into wars against the threat of losing access to water as this could exacerbate their vulnerability in securing food supply for their citizens.

Within this context and through the lens of international trade, we aim at testing whether water plays a strategic role in international relations. Since international trade in ("physical") water is not occurring if not to a limited extent (in the form of bottled water or bulk water), in this paper we consider trade in "virtual water"[137]; the concept, which refers to the volume of water consumed during the entire life-cycle of products, is able to link water, food, and international trade (Allan, 2003).

Following the literature on (heterogeneous) strategic trade interests and conflits (Dorussen, 2006; Goenner, 2010; Reuveny 2003, Li & Reuveny, 2011) we aim at empirically showing that virtual water ("VW") can be considered as a strategic commodity in determining interstate conflicts' probability as compared to (i) trade in commodities widely recognized as "strategic" such as oil, and (ii) trade in non-strategic commodities. Furthermore, as a baseline scenario, we also compare it with the impact of total aggregate trade on conflicts. We thus aim at contributing to this empirical literature by taking into account heterogeneity across trade categories (Goenner, 2010) and across trade flow directions (Li and Reuveny, 2011).

To this purpose, we make use of a logit model alongside a gravity model approach, which is intensively used in international economics (Tinbergen, 1962; Pohyonen, 1963) to explain trade flows. In doing so, the analysis – in line with the gravity approach used by Martin et al. (2008) to test the effect of total trade – will consider the impact of (i) bilateral and (ii) multilateral trade openness on interstate conflicts, and, doing a step forward, also considers the impact of some social network analysis' measures, like (iii) overlapping (how many trade neighbors of the two countries are in common) and (iv) page rank (how much the country considered is central in the trade network). Moreover, we build a novel dataset which, first, distinguishes the direction of trade flows, second, differentiates among attacker and defender in the conflict.

The paper proceeds as follows: Section 2 presents a literature review; Section 3 specifies the data used in the analyses; Section 4 describes the methodologies adopted; Section 5 shows and discusses the results of the analyses; Section 6 concludes.

3.2 Literature review

In the fields of political sciences and political economy, there is a well-established literature addressing the relationship between trade and interstate conflicts. The theoretical debate is between the "trade promotes peace" liberal school and the neo-Marxist school which argues that asymmetric trade links lead to conflicts. As briefly mentioned, the main difference between these two positions comes from the opposing view they have on the possibility of gains from trade for the countries involved. The former position explains the pacific effect of trade in terms of increasing opportunity costs, as trade provides valuable benefits to countries and their populations: trade integration thus inhibits the use of force by increasing the opportunity costs of conflicts (Levy, 2003). The latter position argues that integration, especially when based on asymmetric trade relations, reduces dependence on any one trade partner and creates opportunities for diversion to alternative import and export markets, thus increasing political autonomy. In this case, integration actually reduces the costliness of militarized force and emboldens states, encouraging conflict (Martin et al., 2008).

[136] The Economist, "The Horn of Africa: Chronicle of a famine foretold", July 30th 2011.

[137] Virtual water" refers to the volume of water consumed during the entire life-cycle of products. In the following of this paper, we will refer to virtual water trade as the trade in (water-intensive) agricultural and food products – please refer to the following section on data utilized.

Theorethical studies include Skaperdas and Syropoulos (2001, 2002) who show that terms of trade effects may intensify conflict over resources and Antr'as and Padr'o i Miquel (2011) who study how a dominant country can affect its trading partner's domestic politics to influence the terms of trade. Garfinkel, Skaperdas, and Syropoulos (2011) combine a standard trade model with a contest function for interstate disputes over resources. They show that conflict over resources affects the pattern of comparative advantage, and free trade may intensify armaments so much that autarky may be preferable to free trade.

From an empirical point of view, recent studies have tested the impact of bilateral trade on the frequency of war between country pairs. Many studies find a negative relationship (see for example, Mansfield, 2000). However, some recent studies have found a positive relationship (see Barbieri, 1996, 2002). In the field of economics, studies have traditionally tested the reverse causal link (the effect of war on trade) and found robust evidence of persistent negative effects of conflicts on trade relationships (see for example Blomberg and Hess, 2006; Glick and Taylor, 2005).

Most of the attention in this literature focuses on dyadic or bilateral interdependence; much less attention has been paid to the effects of multilateral trade. However, as remarked by Kinne (2012), dyadic interdependence provides little information about the integration of states into global markets; a pair of countries might, for example, trade heavily with one another but they may lack trade ties to the rest of the network.

Multilateral trade has recently been addressed by Martin et al. (2008) who analyse theoretically and empirically the relationship between military conflicts and trade (bilateral and multilateral), by utilizing a measure of trade openness. They show that the conventional wisdom that trade promotes peace is only partially true even in a model where trade is economically beneficial, military conflicts reduce trade, and leaders are rational. They find that when war can occur because of the presence of asymmetric information, the probability of escalation is lower for countries that trade more bilaterally because of the opportunity cost associated with the loss of trade gains. However, countries more open to global trade have a higher probability of war because multilateral trade openness decreases bilateral dependence to any given country and the cost of a bilateral conflict.

Kinne (2012) further argues that common methods of measuring multilateral trade, such as trade openness, do not capture the complex interdependencies that affect conflict behavior. He develops a social networks approach to trade, focusing specifically on the concept of network centrality to test whether trade integration increases or reduces a country's probability of entering into militarized disputes. In fact, he notes that trade integration may either be seen as a source of constraint on countries, as it deters conflict by increasing the opportunity cost associated with use of force, or alternatively as a source of autonomy, as the declining value of individual trade ties correlates with an increase in opportunities for diversion and substitution. Thus, countries with many partners derive, on average, less utility from each trade tie and can more easily replace lost ties. The measure of centrality he uses is set as to simultaneously capture three facets of trade integration: the breadth of states' trade ties; the strength or depth of trade ties; and the ''commercial distance'' between states that lack direct trade ties. He finds that network centrality unilaterally constrains aggression: more central states initiate fewer conflicts, even when their trade ties are highly asymmetric.

Li and Reuveny (2011) note that all prevailing theories focusing on trade openness and conflict seem plausible, though none fully examines the role of market forces and heterogeneity across trade flows and economic sectors.

Dorussen (2006) points out that empirical studies on trade and conflict generally make use of highly aggregated data, however there are good theoretical arguments to suspect that trade in some goods should have a bigger impact on the likelihood of conflict than trade in others. He examines the relationship between trade and conflict at a lower level of aggregation and finds that trade generally reduces the likelihood of conflict, the relationship is weaker for commodities that are more easily appropriable by force, and the relationship is generally stronger for manufactured goods.

Along the same line, Goenner (2010) argues that the volume and pattern of commodities that countries trade with each other are both relevant to interstate conflict. He notes that commodities are heterogeneous and thus vary in terms of their strategic importance, substitutability, and ease of

expropriation. He finds that increasing the share of bilateral trade in energy, non-ferrous metals, and electronics increases conflict, whereas for chemicals and arms it reduces conflict; differences in the strategic commodities' elasticity of import demand and export supply, along with their ease of expropriation, contribute to these heterogeneous effects.

Another strand of the literature which this paper refers to deals with the relationship between (civil and interstate) conflicts and control over scarce resources, which is a topic which continues to receive a great deal of attention in both the public debate and the literature. Relevant literature started with Bakeless (1921), in what has probably been the first study to address the causes of modern wars[138]; he argued that the vast majority of modern wars had significant economic causes, often related to conflict over resources. Wright (1942), Richardson (1960) and Westing (1986) agree that many of the wars in the twentieth century had an important resource dimension, for example the Algerian War of Independence from France (1954–1962) and the Chaco War between Bolivia and Peru (1932–1935) with reference to oil, the conflict between Argentina and Uruguay over control of the minerals-rich territory of the Rio de la Plata, or the Six Day War (1967) fought by Israel and the neighboring states of Egypt, Jordan and Syria for access to the water resources of the Jordan river[139].

There is a wide-ranging academic literature on the relationship between conflicts and valuable mineral resources, in particular oil.

For the case of interstate conflicts, such relationship has been recently addressed by Acemoglu et al. (2012), who developed a dynamic theory of trade and war between a resource-rich and a resource-poor country; they investigate the interaction between resources scarcity and the incentives for resource-poor countries for entering into a conflict for gaining control over those natural resources, and find that the elasticity of demand plays a key role for determining the incentives for entering into a conflict.

Caselli et al. (2015) make use of information on the distance of natural resource deposits from country/region/ethnic homeland borders. They establish a theoretical and empirical framework to assess the role of resource endowments and their geographic location in interstate conflicts. The main predictions of their theoretical framework are that conflict is more likely when at least one country has natural resources, when the resources in the resource-endowed country are closer to the border, and, in the case where both countries have natural resources, when the resources are located asymmetrically vis-à-vis the border.

Another strand of the literature has theoretically and empirically tested the role of natural resources in civil conflicts, pointing at the fact that natural-resource deposits are often implicated in civil and ethnic conflicts. Most recent studies find robust empirical evidence that localities producing oil are more prone to civil violence – see for example Dube and Vargas (2013). Ploeg (2011) also finds that intergroup conflict is more likely when total resources are more concentrated in one of the ethnic groups' homelands.

By contrast, the academic literature on the relationship between conflicts and control over scarce environmental resources, such as water, is not well developed yet, and it is still struggling to find robust evidence of correlation between water scarcity and conflicts. Homer-Dixon (1999) argues that "environmental scarcity has often spurred violence in the past" and that "in coming decades the world will probably see a steady increase in the incidence of violent conflict caused, at least in part, by environmental scarcity". However, he has also made it clear that he cannot identify any clear "causal effect".

Generally, recent studies find ambiguous support for a scarcity theory of water conflicts; the only exception is possibly for those studies specifically addressing the cases where a river basins is shared among countries in an upstream/ downstream relationship (e.g. Gleditsch, 2000) [140].

[138] Bakeless (1921) studied interstate wars occurred in the period 1878-1918.

[139] Just before the Six Day War between Israel and its Arab neighbors, Prime Minister Levi Eshkol declared that "water is a question of survival for Israel", and therefore "Israel will use all means necessary to secure that the water continues to flow" (Biliouri, 1997).

[140] Gleditsch (2000) finds that a joint river does indeed increase the probability of militarized disputes and armed conflict over and above mere contiguity. This risk factor is comparable in size to standard control variables, but much smaller than the effect of contiguity itself. Water scarcity is also associated with conflict, and the upstream/downstream relationship appears to be the form of shared river most frequently associated with conflict.

This paper also draws from another strand of literature, which, as far as we know, has never been studied in conjunction with interstate conflicts, regarding the concept of "virtual water", originally proposed by Allan (1997, 1998) who observed that food import of water scarce countries implies an import of the water embedded in the traded commodities. The concept of virtual water has been in use for two decades now and it has gained wide attention both in the scientific discussions as well as in the political debate[141], becoming central to many dialogues relating to water security and water policy. The term has been able to draw attention in the public debate to the notion that serious local water shortages could be very effectively addressed by global economic processes.

In fact, currently about 85% of all (fresh) water is used for agriculture and food production, and agricultural products are traded internationally[142]: the concept of "virtual water trade" thus refers to the opportunity to minimize water consumption in water-short countries by increasing imports of products that require a large amount of water in their production cycle (water-intensive products) and to limit the export of water-intensive goods from such countries. In other words, water-scarcity problems of arid or semi-arid regions could be alleviated if water-intensive goods are being produced in water-rich regions and imported into arid countries, whereas non-water-intensive products are being produced in water-scarce regions.

Thus, against the political rethoric, Professor Tony Allan brought under general attention that, rather than going into some (predicted) wars about the scarce resource water, the water-scarce countries in the Middle-East successfully compensated their fresh water shortages by importing virtual water, in the form of water intensive food products such as wheat and rice (Allan 1997, 2003)[143].

Reimer (2012) gives economic foundations to the virtual water concept through the international trade theory of Heckscher-Ohlin-Vanek according to which commodity trade can be seen as an implicit exchange in the factors of production "embedded" in the commodities, in line with the interpretation of the factor content of trade accepted in international trade theory (Davis and Weinstein, 2003).

The virtual water trade (VWT) and the corresponding trade network have been investigated in many recent studies and with different approaches (Hoekstra and Hung, 2002; Lenzen, 2009; Konar et al., 2011, D'Odorico et al., 2012; Carr et al., 2013, Tamea et al., 2013).

The VWT contributes to food security, allowing water-scarce countries to benefit from water resources available elsewhere and to meet the food (and associated water) requirements of a growing population (Godfray et al., 2010; Rosegrant et al., 2002). On a different ground, the VWT determines an externalization of resources, an increase in country interdependency and a reduced resilience of society to food and water crises (Seekell et al., 2011; Porkka et al., 2013).

3.3 Data utilized for the analyses

In this paper we utilize as a starting point the data and methods utilized by Martin et al. (2008) in their paper, which they make available through their website. The dataset include data on conflicts, total bilateral and multilateral trade, distance between countries, geographic areas of countries, history of country's UN voting over security issues, the existence of free trade agreements, membership to GATT (before 1995) / WTO organization (after 1995), the presence of common languages and colonial ties between country pairs.

The data utilized by Martin et al. (2008) are not directed in the country pair, for example data on bilateral trade between country *i* and country *j* include both export from *i* to *j* as well as export from *j* to *i*. As mentioned, in this paper we replicate this method and analyses, but we also distinguish the direction of trade flows between country pairs, by treating differently import from export operations.

[141] See Allan, J. A. (2003), Virtual water - the water, food and trade nexus: Useful concept or misleading metaphor? Water International 28(1): 106-113.

[142] Hoekstra, A. Y. and P. Q. Hung (2002), Virtual Water Trade, A Quantification of Virtual Water Flows Between Nations in Relation to International Crop Trade, Value of Water Research Report Series No. 11, Delft, Netherlands, UNESCO-IHE Institute for Water Education.

[143] Professor Tony Allan was inspired by Israeli concerns not to 'over-export' water intensive agricultural products in view of emerging local water scarcity. "Virtual water" refers to the volume of water consumed during the entire life-cycle of products. In the following of this paper, we will refer to virtual water trade as the trade in (water-intensive) agricultural and food products – please refer to the following section on data utilized.

The data on conflicts used in this paper come from the COW project (at http://cow2.la.psu.edu/) that makes available a wide-ranging and precise description of interstate armed conflicts. The main dependent variable is the occurrence of a conflict (MID) between a pair of countries. This data set is available for the years 1816–2001, but we only use the years 1986–2000 because this is the period for which one of our principal explanatory variable, virtual water trade, is available.

In the COW data set, MID is coded with a hostility level ranging from 1 to 5 (1 = No militarized action, 2 = Threat to use force, 3 = Display of force, 4 = Use of force, and 5 = War), and War is defined as a conflict with at least 1000 deaths of military personnel. By this standard, fewer than 100 interstate wars have been fought since 1815. At the country pair level of analysis, the number of pairs of states at war is naturally larger, since in multi-state wars, each state on one side would be paired with every state on the other. Even so, the small number of warring country pairs inhibits the creation of truly robust estimates of war determinants. Consequently, in line with Martin et al. (2008), all those events occurred between country pairs defined in the dataset with an hostility level equal to 3 or above[144] are defined as a conflict (MID); the MID variable thus assumes value equal to 1 in correspondence of the country pairs and years for which an even classified in the dataset with an hostility level of 3, 4 or 5, and it assumes the value 0 otherwise. Our sample consists, for each year of the 1986–2000 period, of all existing country pair combinations ("dyads"); of this sample of dyads, few are engaged in an MID, even with our enlarged definition.

We will also use a different specification of the principal dependent variable MID, which we call MID_NEW, taken from the COW dataset (COW 2.0 dyadic dataset), which distinguishes the direction of conflict by providing information on which country within the dyad has originated the conflict. If country *i* has initiated the conflict, the variable MID_NEW assumes value equal to 1, and it assumes value equal to 0 in all other cases (when the dyad in that year did not enter into a conflict, or whether there was a conflict but initiated from country *j*).

Our final cleaned bilateral dataset, which is a panel of 15 years representing all directed country pairs, contains 281,744 observations. In all, as expected, the number of observations where a conflict is held is really small, and it stands to 917, corresponding to the 0.325 % of the total sample. This number is consistent with the one in Martin et al. (2008) which reports a conflict ratio which is 0.511% of the total sample.

Data on total bilateral and multilateral total trade, trade in oil and gas, and trade in footwear, are taken from the NBER-UN Trade Data set (http://cid.econ.ucdavis.edu/data/undata/undata.html), providing data on both total and sectorial trade between country pairs for the period 1962-2000. Data on oil and gas trade are extracted based on the SITC4 codes of the commodities traded[145]. Data on virtual water trade are reconstructed on the basis of data from Food and Agricultural Organization of the United Nations, Statistics Division (Faostat), for the international trade of 309 agricultural commodities exchanged from country of origin *i* to country of destination *j*. These data refer to the 'blue' and the 'green' components of the water-footprint of the products traded[146].

Data on individual countries' GDP are taken from the World Bank dataset; these data are utilized for calculating bilateral and multilateral trade openness. Variables accounting for bilateral trade impediments or facilitating factors (distance, contiguity, and colonial links) and for geographic areas come from the CEPII bilateral distance database (www.cepii.fr/anglaisgraph/bdd/distances.htm) utilized in standard gravity models.

[144] Examples of display of force (level 3 of an MID) include a decision of mobilization, a troop or ship movement, a border violation, or a border fortification. These are government-approved and unaccidental decisions. Examples of use of force (level 4 of a MID) include a blockade, an occupation of territory, or an attack.

[145] Data utilized for the category "trade in oil and gas" are those extracted under the SITC4 code Division: 33 ("Petroleum, petroleum products and related materials") and Division: 34 ("Gas, natural and manufactured").

[146] The water footprint of a product is the volume of water needed to produce the product. The 'blue' water footprint refers to the volume of surface and groundwater consumed (evaporated) as a result of the production of a good; the 'green' water footprint refers to the rain-water consumed. The 'grey' water footprint of a product refers to the volume of freshwater that is required to assimilate the load of pollutants based on existing ambient water quality standards – please refer to Mekonnen and Hoekstra (2011).

Finally, information on democratic status of individual countries derive from the Polity IV database, which provides the composite index that ranks countries on a −10 to +10 scale in terms of democratic institutions utilized in the paper.

3.4 Methodologies adopted for the analyses

In line with Martin et al. (2008) we start the analysis with estimating the impact of bilateral and multilateral trade openness on military conflicts in order to test their model's predictions related to the contradictory effects of bilateral and multilateral trade on conflicts[147]. The estimation is made through a gravity equation in a logit form, where the probability of escalation depends on the traditional gravity controls, such as distance (in logarithmic form), common language, geographical contiguity, colonial relationship and free trade agreements. Also, the model considers the number of years of peace between the two countries and the democracy index. GDPs, as a proxy for country dimension, are not directly used, but they are considered as we control for bilateral and multilateral trade, which are standardized by means of GDPs. Moreover, in the fully specified model, the model take into account for the sum of the areas of the two countries belonging to the pair.

First, we replicate their analysis with total non-directed total trade, where bilateral trade openness is calculated as the simple arithmetic average of bilateral import flows over the sum of their GDPs:

$$Bil\_trade_{ijt} = (imp_{ijt} + imp_{jit}) / (GDP_{it} + GDP_{jt}) \quad (1)$$

and multilateral trade openness is calculated as the arithmetic average of total imports of the two countries excluding their bilateral imports divided by the sum of their GDPs:

$$Multi\_trade_{ijt} = (\sum_{j \neq i} imp_{ijt} + (\sum_{i \neq j} imp_{jit}) / (GDP_{it} + GDP_{jt}) \quad (2)$$

In the model utilized by Martin et al. (2008) the probability that a conflict occurs is determined as the probability of a dispute between countries *i* and *j* multiplied by the conditional probability of escalation, as follows:

$$\Pr(MID_{ijt}) = \Pr(dispute_{ijt}) \times \Pr(escalation_{ijt} \mid dispute_{ijt}) \quad (3)$$

They found therefore essential in the regressions to take into account the cross-sectional variation of disputes: consistently with data utilized and with literature's findings, they emphasized the role of distance between countries in the dyad. First, they restricted the sample to those country pairs that are most likely to have a high probability of disputes, namely those with a border and those with a bilateral distance below 1000 km; this reduced greatly the size of the sample considered here. The second strategy was to keep the full sample of countries and to add interaction terms between distance and trade variables.

Furthermore, they took into account in their regressions the possible endogeneity issues in the relationship between bilateral trade and military conflicts; in fact, a negative correlation between trade openness and the probability of military conflicts can arise with causality running both ways. To prevent these issues, they first considered a 4-year lag for bilateral and multilateral openness variables in order to limit contemporaneous reverse causality. Then they also controlled for several variables that could be co-determinants of conflicts and trade patterns as well as for country pair fixed effects by exploiting the panel dimension of their data set.

Therefore, as in Martin et al. (2008), we utilize six different regression models, where the first four models are estimated by means of a pooled-panel logit regression while models five and six are

[147] In particular, a negative impact of bilateral trade openness on the probability of MID but a positive impact of multilateral trade openness
on the probability of MID.

estimated using a country fixed effects approach (model 5 is a logit, while model 6 is a linear probability model (LPM)). The first two regressions represent our preferred specifications which we'll keep using in the course of the analysis for purposes of comparison; the other four regressions were run under all scenarios considered as robustness checks. The first regression (model 1) addresses the cross-sectional variation of disputes by limiting the sample to contiguous country pairs; this also typically represents the most frequent case of interstate conflicts (see Toset et al., 2000). Model 2 considers the full sample with interaction terms between distance and the trade variables and with a long series of controls, in line with the literature on gravity equation (including cultural and colonial ties, UN vote correlation, common language, size/area of the countries, democratic status, existence of free trade agreements, etc.). The third regression integrates model 1 and considers contiguous country pairs and countries with a distance below 1,000 km. Model 4 considers the full sample with interaction terms between distance and the trade variables without the full list of controls included in the second regression. The fifth and sixth regressions replicate regression 2 and add country pair fixed effects: regression 5 limits the sample to those country pairs having a conflict in the period considered, whereas regression 6 considers the full sample with a standard linear fixed effect specification.

In our analyses we maintain the same regression models just described - Appendix 1 shows the results considering total (non-directed) bilateral and multilateral trade openness as explanatory variables, which coincide with results found in Martin et al. (2008)[148].

We then repeat the same exercise with the same settings but with different explanatory variables: instead of total total trade, we test the impact on conflicts of bilateral and multilateral virtual water trade as well as bilateral and multilateral trade in oil and gas. Appendix 1 shows the results also for these categories of trade as compared to total trade.

Then, we depart from the model utilized by Martin et al. (2008) and we construct a bi-directed data set, in order to distinguish between the direction of trade. Accordingly, we modify the measure of bilateral and multilateral trade openness: in this new set-up, bilateral trade openness of country *i* is calculated as the ratio of bilateral import flow over the importing country's GDP, and multilateral trade openness is calculated as the sum of imports from third countries (excluding bilateral import flow) divided by the GDP.

$$Bil\_trade_{ijt} = imp_{ijt} \,/\, GDP_{jt} \tag{4}$$

$$Multi\_trade_{ijt} = \sum_{j \neq i} imp_{ijt} \,/\, GDP_{jt} \tag{5}$$

We construct these measures for both total trade, oil and gas trade, and virtual water trade. In line with Martin et al. (2008) and also to account for possible endogeneity issues, we also compare the impact of trade openness measures with the corresponding 1-year and 2-years lagged measures (contrary to Martin et al, we do not use 4-years lagged measure, in order to preserve degrees of freedom in our 15-years panel dataset).

In this new set-up, we consider first as a dependent variable the variable MID, which does not distinguish which country in the dyad has originated the conflict and which country was instead attacked. We then repeat the same exercise with the new dependent variable MID_NEW, which provides this type of information, in order to better exploit the characteristics of the bi-directed data set which we constructed.

Finally, in order to account for the remarks by Kinne (2012) about the limits of the ability of measures such as trade openness to capture the complex dynamics of interdependency among countries ultimately leading to their conflict behavior, we replace as the main explanatory variables different network metrics to the measures of trade openness previously utilized.

In the trade network considered, nodes are independent countries and edges are trade relations among nodes. We use both network's segmentation and actor's centrality metrics, testing whether trade

[148] Please refer to Table 3 of the paper from Martin et al. (2008).

centrality acts as a source of constraint (limiting the use of force) or, vice versa, as a source of autonomy (thereby, increasing propensity to conflict) for the countries.

The network metrics that we considered are the following:

a) Number of ties: this is a country specific variable that represents, for each single year, how many neighbors the country have, in terms of 1) total trade, 2) trade in oil and gas, 3) trade in virtual water, 4) trade in footwear. A neighbor is considered so, if the level of imports to that country (normalized by the sum of their GDPs) is on the right tail (10%) of the distribution.
b) Overlapping: this variable represents, for each country pair in each year, how many neighbors they share. This measure is computed for the three trade categories. We computed this variable using MATLAB.
c) Weighted and unweighted cluster coefficient: this variable represents how much the neighbours of a certain country, in a certain year, are clustered toghether, in terms of 1) total trade, 2) trade in oil and gas, 3) trade in virtual water, 4) trade in footwear. We computed this variable in R using *clustering_local_w* function in *tnet* package.
d) Page rank: it is a measure of the influence of a node in a network. It assigns relative scores to all nodes in the network based on the concept that connections to high-scoring nodes contribute more to the score of the node in question than equal connections to low-scoring nodes. It is a variant of the eigenvector centrality measure. We compute it for every country in every year for 1) total trade, 2) trade in oil and gas, 3) trade in virtual water, 4) trade in footwear, using *page_rank* function in *igraph* package.
e) Similarity index: based on the export similarity index proposed in the trade literature by Finger and Kreinin (1979), we constructed an import similarity index between country pairs based on the share of their respective sourcing of the commodities considered from each country of origin. We computed this variable using MATLAB.

We run the same regressions above-described with these different network metrics, each as a single dependent variable and also in combination among themselves, for all the different categories of trade considered. Furthermore, in line with Kinne (2012), we also compare the effect of trade integration with the effect of trade openness.

3.5 Results and discussion

We start the regression exercises with replicating the analysis of Martin et al. (2008), where the explanatory variables considered are total bilateral and multilateral trade, the data set utilized does not contemplate distinctions based on direction of trade flows, and the dependent variable investigated (MID) did not distinguish in the dyad between the country which originated the conflict and the country which was the respondent. We then analyze, with the same (non-directed) dataset and the same setting, the impact of bilateral and multilateral virtual water trade openness on the probability of conflict, by considering trade in virtual water as main explanatory variable replacing total trade. For purposes of comparison, within the same setting, we also test trade in oil (oil and gas), which as already explained is a traditionally considered, in both academic literature and the public debate, as a commodity who has played and continues to play a strategic role in international relations.

Globally, we find results consistent with findings from Martin et al. (2008), which point out opposite effects of bilateral and multilateral trade openness on the probability of war: with regard to bilateral trade, the probability of escalation to war is lower for countries that trade more bilaterally; this result supports the view that bilateral trade increases the opportunity costs of bilateral conflicts, thereby deterring countries from entering into conflicts. By contrast, countries more open to global trade have a higher probability of war; this result supports the view that multilateral trade openness decreases bilateral dependence to any given country and therefore it decreases the opportunity cost of a bilateral conflict, by weakening the incentive to make concessions to prevent escalation to conflict.

Appendix 1 sums up the results in our preferred specifications (model 1 for contiguous countries and model 2 with the full sample and the full set of control variables) and it highlights a first

evidence of heterogeneous effects among sectors. In fact, the results indicate a larger negative effect of bilateral trade openness in virtual water and, especially, in oil than considering total trade, whereas the effect of multilateral trade openness considering oil and virtual water is less significant than considering total trade. In particular, the coefficients found for bilateral trade openness in oil and in virtual water are larger (under all models and specifications), than the corresponding coefficients found by Martin et al. (2008), pointing at a larger (bilateral) dependency effect between countries when considering trade in virtual water, and trade in oil, compared to total trade. This is a first indication that virtual water plays a strategic role, similarly to oil.

Estimates found for the control variables utilized are consistent and similar to estimates found by Martin et al. (2008) in the case of total trade openness.

We then utilize the directed dataset that we constructed, in order to single out information on the direction of trade, and we utilize as a dependent variable the variable MID and also the variable MID_NEW in order to exploit this information. Appendix 2 shows the results achieved in our preferred specifications with the new dataset for what concerns the impact on MID of trade openness in virtual water, as compared to the impact of trade in oil (considered as a benchmark for strategic commodities), trade in footwear (considered as a benchmark for non-strategic commodities[149]), and total trade (baseline scenario). This scheme for comparison will be kept constant for all remaining analyses for purposes of comparison and thus for determining whether trade in virtual water plays a strategic role in international relations or not.

The results found with the directed dataset and keeping the same dependent variable MID are generally consistent with the results found from Martin et al. (2008); however, they seem to point out a larger and more significant effect of bilateral trade openness as a deterrent from entering into conflicts (for virtual water, oil and total trade as well), whereas, contrary to Martin et al. (2008), they indicate a less significant role being played by multilateral trade openness. In particular, coefficients found for bilateral trade openness in virtual water are statistically significant in both our preferred specifications, whereas for oil coefficients are not significant in the specification considering contiguous countries only. Trade in footwear is not significantly associated with conflicts in all our specifications, taking into consideration both bilateral and multilateral trade openness' measures.

We also separately considered 1-year and 2-year lagged explanatory variables, for all categories of trade investigated. When testing trade in oil and gas and virtual water trade, results do not change much when considering lagged variables instead of contemporary ones, even though a trend is recognizable in having the 1-year lagged variables having a smaller and less significant effect than the contemporary ones, whereas the 2-year lagged variables have similar coefficients than the contemporary ones. Instead, when testing total trade and taking into consideration contemporary variables, the result for multilateral trade openness does not have the sign expected for in our preferred specification (model 2) and it points at an effect for multilateral trade that deters the use of force; it only assumes the sign expected for when considering 1-year and 2-year lagged variables[150].

We then considered the new (directed) dependent variable MID_NEW; the results found are further strengthened, in magnitude and in significance. Table 1 shows the results achieved from running the six regressions models for virtual water trade. Results found point at a large and significant effect of both bilateral and multilateral trade openness on probability of conflicts; the effect of bilateral virtual water trade openness is significant both in our preferred specification and, at a lower degree, for contiguous country pairs (model 1) as it deters importing countries from entering into conflicts. The coefficients found for multilateral virtual water trade openness are significant in our preferred specification (model 2) and consistent with the results found by Martin et al. (2008) as it decreases the opportunity costs of the use of force for importing countries.

[149] Footwear (i. e. SITC classification code 85) has been considered as a benchmark for non-strategic commodities on the basis of previous literature on the relationship between disaggregated trade and conflicts, in particular on the basis of findings from Dorussen (2006) and Goenner (2010).

[150] Results are available in the web appendix.

TABLE 1 – Estimated coefficients of virtual water (VW) trade openness on conflicts (MID_NEW) - directed dataset

VARIABLES	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Bilateral VW trade open	-0.334*	-2.067**	-0.323	-2.858***	-0.012	0.022
	(0.176)	(0.879)	(0.236)	(0.752)	(0.856)	(0.044)
Multilat. VW trade open	-0.012	1.144***	-0.049	0.995***	0.541	-0.005
	(0.060)	(0.376)	(0.088)	(0.293)	(0.477)	(0.015)
ln distance * bilateral VW		0.265**		0.397***	-0.036	-0.004
		(0.119)		(0.098)	(0.118)	(0.005)
ln distance * multilat. VW		-0.179***		-0.166***	-0.088	0.000
		(0.051)		(0.039)	(0.065)	(0.002)
UN vote correlation t-4		-0.952***			-0.844***	0.006
		(0.248)			(0.296)	(0.007)
sum of democracy indexes		0.165			-0.191	0.004
		(0.183)			(0.286)	(0.005)
# other wars in t		0.135***			0.158***	0.003***
		(0.017)			(0.011)	(0.000)
ln distance to nearest war t		-0.220*			-0.672***	-0.022***
		(0.120)			(0.126)	(0.003)
sum ln areas		0.290***				
		(0.040)				
1 if alliance active in t		0.076			0.091	-0.052***
		(0.194)			(0.406)	(0.016)
ln distance	-0.270*	-0.814***	-0.347	-0.107		
	(0.147)	(0.158)	(0.312)	(0.162)		
common language		0.308				
		(0.242)				
Contiguity		0.831***		1.401***		
		(0.289)		(0.296)		
pair ever in colonial relationship		0.734***				
		(0.280)				
common colonizer		0.365				
		(0.268)				
free trade area (full set)		-0.375			-0.284	0.013
		(0.290)			(0.416)	(0.013)
# of GATT members		0.217			-0.487**	-0.012***
		(0.138)			(0.225)	(0.004)
Observations	6,680	213,962	3,744	213,962	4,926	213,962
Sample	Contiguous pairs	Full	Contiguous pairs and <1000 km	Full	Full	Full
Time dummies	No	Yes	No	No	Yes	Yes
Dyadic war lags	No	Yes	No	No	Yes	Yes
Dyadic same war lags	No	No	No	No	No	Yes
Estimation method	Logit	Logit	Logit	Logit	FE Logit	FE LPM
Pseudo R-squared	0.137	0.513	0.138	0.368	0.233	0.202

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, *p<0.1

Column 1: contiguous country pairs only. Column 2: full sample with interaction term and complete set of controls. Column 3: proximate countries only. Column 4:. full same with interaction terms. Column 5: full sample with country pair fixed effects logit model. Column 6: full sample with country pair fixed effects linear probability model (LPM).

TABLE 2 – Estimated coefficients of trade openness on conflicts (MID_NEW) – directed dataset

	Oil&Gas Trade		**Virtual Water Trade**		**Footwear Trade**		**Total Trade**	
VARIABLES	Model (1)	Model (2)	Model (1)	Model (2)	Model (1)	Model (2)	Model(1)	Model(2)
bilateral trade openness	0.043	-6.624***	-0.334*	-2.067**	0.021	0.189	-0.409*	-3.128**
	(0.536)	-2.129	(0.176)	(0.879)	(0.069)	(0.245)	(0.245)	-1.559
multilateral trade openness	0.074	0.769	-0.012	1.144***	-0.008	-0.033	-0.055	0.085
	(0.097)	(0.584)	(0.060)	(0.376)	(0.009)	(0.034)	(0.063)	(0.381)
ln distance * bilateral trade openness		0.796***		0.265**		-0.026		0.355*
		(0.242)		(0.119)		(0.033)		(0.193)
ln distance * multilateral trade openness		-0.106		-0.179***	-0.088	0.005		-0.014
		(0.074)		(0.051)	(0.065)	(0.004)		(0.051)
Observations	6,680	213,962	6,680	213,962	6,181	200,953	6,680	213,962
Sample	Contiguous pairs	Full	Contiguous pairs	Full	Contiguous pairs	Full	Contiguous pairs	Full
Time dummies	No	Yes	No	Yes	No	Yes	No	Yes
Dyadic war lags	No	Yes	No	Yes	No	Yes	No	Yes
Dyadic same war lags	No	No	No	No	No	No	No	No
Estimation method	Logit	Logit	Logit	Logit	Logit	Logit	Logit	Logit
Pseudo R-squared	0.094	0.355	0.095	0.356	0.133	0.512	0.096	0.355

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, *p<0.1

Model 1: contiguous country pairs only. Model 2: full sample with interaction term and complete control set. The table does not show the controls included (number of peaceful years, UN vote correlation, number of other wars, democratic status, colonial ties, distance from nearest war, areas, membership to active alliance, contiguity, common language, existence of a free trade area, GATT membership) for space limitation.

Table 2 shows the regression coefficients achieved in our preferred specifications comparing virtual water trade to trade in oil, trade in footwear and to total trade. Results found point at a significant effect of bilateral trade openness on probability of conflicts for all categories of trade considered, with the exception of trade in the non-strategic commodity footwear; the effect of bilateral virtual water trade openness is significant both in our preferred specification and, at a lower degree, for contiguous country pairs (model 1) as it deters importing countries from entering into conflicts. Results found for bilateral trade openness in oil are consistent and even more significant in our preferred specification, whereas coefficients are not significant in the case of contiguous country pairs. This comparison seems to confirm the strategic role played by virtual water (bilateral) trade in international relations. The coefficients found for multilateral virtual water trade openness are significant in our preferred specification (model 2) and again point out at a reduction of the opportunity costs of the use of force for importing countries. On the contrary, results found for (multilateral) trade in oil[151] and for total trade have the expected sign but are not significant in both model regressions shown, and coefficients found for trade in footwear are not significant neither have the expected sign. This comparison, again, seems to be confirming the strategic role played by virtual water (multilateral) trade in international relations.

[151] However, it is significant (even though at a lower degree compared to the other categories of trade) for proximate and contiguous countries (model 3) and with standard logit model (model 4) – full results are available in the web appendix.

Then, in order to account for the remarks expressed by Kinne (2012) regarding the limits of trade openness' measures to capture the complex dynamics of interdependency among countries, we adopt a social network analysis' approach to trade and utilize as the main explanatory variables the different network metrics and similarity indexes described in the previous section.

We run the same regressions as in Martin et al (2008) with these different metrics, for virtual water trade as compared to trade in oil and gas and to trade in footwear, and also with total trade as a baseline scenario; we start with using separately the single centrality measures as explanatory variable. Then, in line with Kinne (2012), we utilize as explanatory variables the different network metrics together with measures of trade openness. As a dependent variable, we separately use both variables MID and MID_NEW.

Kinne (2012) finds strong evidence that trade integration, measured in terms of his three-tiered network centrality measure, substantially reduces a state's likelihood of initiating militarized disputes, whereas trade openness, on the other hand, yields insignificant estimates.

Utilizing the number of ties as network metric we derive insignificant estimates under our preferred specification (model 2), even though the estimates found are consistent with those found for multilateral trade openness and suggest a positive effect of trade integration into the probability of conflicts[152]. Also utilizing the weighted (wcc) and unweighted (cc) cluster coefficients we achieve insignificant estimates under our preferred specification (model 2); however, results generally indicate a negative effect of trade integration into the probability of conflicts, with centrality unilaterally restraining country's probability of using force. Estimates found for the control variables utilized are consistent and similar to estimates found by Martin et al. (2008)[153].

When utilizing overlapping, we find significant estimates for virtual water trade and for trade in oil and gas (even though only at 10% level), whereas we find insignificant estimates for total trade. We achieve under our preferred specification (model 2) opposite results compared to Kinne (2012), pointing out a positive effect of a country pair's overlapping on their probability of entering into a bilateral conflict, with integration thus empowering countries in their international relations. However, estimates found for contiguous countries (model 1) are negative and non-significant for all categories of trade. Table 3 shows the results.

[152] Results are available in the web appendix.

[153] Results are available in the web appendix.

TABLE 3 - Estimated coefficients of trade openness and overlapping on conflicts (MID_NEW) – directed dataset

	Oil&Gas Trade		**Virtual Water Trade**		**Total Trade**	
VARIABLES	Model (1)	Model (2)	Model (1)	Model (2)	Model (1)	Model (2)
bilateral trade openness	0.121	-6.151***	-0.363*	-2.039**	-0.443*	-3.062*
	(0.496)	-2.155	(0.188)	(0.869)	(0.250)	-1.610
multilateral trade openness	0.083	0.549	-0.005	1.130***	-0.045	0.040
	(0.102)	(0.618)	(0.061)	(0.414)	(0.069)	(0.405)
ln distance * bilateral trade openness		0.751***		0.278**		0.353*
		(0.245)		(0.116)		(0.199)
ln distance * multilateral trade openness		-0.076		-0.183***		-0.011
		(0.078)		(0.056)		(0.054)
Overlapping	-0.433	0.305*	-0.234	0.585***	-0.238	0.323
	(0.273)	(0.174)	(0.272)	(0.178)	(0.252)	(0.220)
Observations	6,201	205,025	6,585	212,428	6,343	207,667
Sample	Contiguous pairs	Full	Contiguous pairs	Full	Contiguous pairs	Full
Time dummies	No	Yes	No	Yes	No	Yes
Dyadic war lags	No	Yes	No	Yes	No	Yes
Dyadic same war lags	No	No	No	No	No	No
Estimation method	Logit	Logit	Logit	Logit	Logit	Logit
Pseudo R-squared	0.090	0.350	0.095	0.357	0.095	0.356

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, *p<0.1

Model 1: contiguous country pairs only. Model 2: full sample with interaction term and complete control set. The table does not show the controls included (number of peaceful years, UN vote correlation, number of other wars, democratic status, colonial ties, distance from nearest war, areas, membership to active alliance, contiguity, common language, existence of a free trade area, GATT membership) for space limitation.

When utilizing page rank, estimates found for total trade and for trade in oil and gas are positive and significant also in the case of contiguous and proximate country pairs, pointing at trade integration increasing the power of countries and their propensity to enter into conflicts. Results found for virtual water are not significant under both our preferred specifications (model 1 and model 2); they indicate a positive effect of trade integration on conflicts probability for the country attacked in the conflict, whereas trade integration reduces the likelihood of countries to initiate a conflict.

Estimates found with regard to the measures of trade openness continue under all scenarios to point at a negative and significant effect of bilateral trade openness on conflicts' probability and an opposite effect played by multilateral trade openness. Table 4 shows the results.

TABLE 4 – Estimated coefficients of trade openness and page rank on conflicts (MID_NEW) – directed dataset

	Oil&Gas Trade		**Virtual Water Trade**		**Footwear Trade**		**Total Trade**	
VARIABLES	Model (1)	Model (2)	Model (1)	Model (2)	Model (1)	Model (2)	Model (1)	Model (2)
bilateral trade openness	-0.153	-5.139***	-0.306*	-2.224***	0.020	0.218	-0.970**	-2.926**
	(0.605)	-1.496	(0.181)	(0.854)	(0.069)	(0.280)	(0.429)	-1.235
multilateral trade openness	0.194*	0.248	-0.013	1.269***	-0.010	-0.032	-0.046	0.059
	(0.101)	(0.441)	(0.066)	(0.416)	(0.010)	(0.036)	(0.071)	(0.362)
ln distance * bilateral trade openness		0.622***		0.297***		-0.029		0.325**
		(0.168)		(0.115)		(0.038)		(0.149)
ln distance * multilat. trade openness		-0.028		-0.200***		0.004		-0.009
		(0.054)		(0.056)		(0.005)		(0.047)
Page rank *i*	0.008	9.048*	-1.247	-7.189	-54.128	-100.138*	39.833*	25.175**
	-8.538	-4.841	-15.260	-11.815	(66.504)	(56.329)	-20.749	-9.993
Page rank *j*	-11.068	9.344*	-6.381	16.279	1.809	47.774	12.298	18.593*
	-8.967	-4.918	-13.420	-10.685	(66.024)	(58.658)	-15.693	-9.801
Observations	5,838	198,594	6,370	210,022	6,097	195,276	5,994	202,670
Sample	Contiguous pairs	Full	Contiguous pairs	Full	Contiguous pairs	Full	Contiguous pairs	Full
Time dummies	No	Yes	No	Yes	No	Yes	No	Yes
Dyadic war lags	No	Yes	No	Yes	No	Yes	No	Yes
Dyadic same war lags	No	No	No	No	No	No	No	No
Estimation method	Logit	Logit	Logit	Logit	Logit	Logit	Logit	Logit
Pseudo R-squared	0.154	0.607	0.133	0.515	0.137	0.516	0.160	0.606

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, *p<0.1

Model 1: contiguous country pairs only. Model 2: full sample with interaction term and complete control set. The table does not show the controls included (number of peaceful years, UN vote correlation, number of other wars, democratic status, colonial ties, distance from nearest war, areas, membership to active alliance, contiguity, common language, existence of a free trade area, GATT membership) for space limitation.

Taking into account the import similarity index jointly with the trade openness measures, we found statistically significant correlation between import similarity of countries in the dyad considered and their propensity to enter into (bilateral) conflicts when considering virtual water trade. This result

indicates an effect of competition over sources of water and food supplies, with countries more willing to enter into conflicts when competition threatens their supplies, and also confirms the strategic role played by virtual water trade in international relations.

Estimates found for trade in both the strategic commodity (oil) and the non-strategic commodity (footwear) are not significant: while this is the expected result for trade in footwear, the result found for trade in oil is quite surprising, and further research on this is needed to fully comprehend such result.

TABLE 5 – Estimated coefficients of trade openness and import similarity on conflicts (MID_NEW) – directed dataset

	Oil&Gas Trade		**Virtual Water Trade**		**Footwear Trade**		**Total Trade**	
VARIABLES	Model (1)	Model (2)	Model (1)	Model (2)	Model (1)	Model (2)	Model (1)	Model (2)
bilateral trade openness	-0.258	-6.655***	-0.349**	-2.001**	0.022	0.345	-0.406	-3.064*
	(0.550)	(2.418)	(0.168)	(0.862)	(0.053)	(0.357)	(0.251)	(1.567)
multilateral trade openness	0.140	1.463**	-0.003	1.285***	-0.002	-0.012	-0.087	0.138
	(0.111)	(0.692)	(0.061)	(0.401)	(0.006)	(0.035)	(0.071)	(0.433)
ln distance * bilateral trade openness		0.813***		0.263**		-0.047		0.348*
		(0.276)		(0.116)		(0.049)		(0.194)
ln distance * multilat. trade openness		-0.197**		-0.205***		0.004		-0.023
		(0.087)		(0.054)		(0.005)		(0.058)
Import similarity	-0.602	0.576	-0.745	0.906**	-1.360	-1.096*	-0.177	0.854*
	(0.477)	(0.475)	(0.555)	(0.426)	(0.899)	(0.658)	(0.796)	(0.442)
Observations	3,760	131,290	6,500	210,918	2,662	92,013	6,076	202,670
Sample	Contiguous pairs	Full	Contiguous pairs	Full	Contiguous pairs	Full	Contiguous pairs	Full
Time dummies	No	Yes	No	Yes	No	Yes	No	Yes
Dyadic war lags	No	Yes	No	Yes	No	Yes	No	Yes
Dyadic same war lags	No	No	No	No	No	No	No	No
Estimation method	Logit	Logit	Logit	Logit	Logit	Logit	Logit	Logit
Pseudo R-squared	0.205	0.540	0.140	0.515	0.236	0.546	0.136	0.516

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, *p<0.1

Model 1: contiguous country pairs only. Model 2: full sample with interaction term and complete control set. The table does not show the controls included (number of peaceful years, UN vote correlation, number of other wars,

democratic status, colonial ties, distance from nearest war, areas, membership to active alliance, contiguity, common language, existence of a free trade area, GATT membership) for space limitation.

Finally, we tested several network metrics in combination among themselves. With regard to total trade, results achieved when investigating the full sample of dyads are not statistically significant, however they generally indicate a negative correlation between countries' centrality and conflicts' probability. However, results are both quantitatively and statistically significant for contiguous and proximate country pairs, which point out a negative correlation among all centrality measures considered and the propensity to conflicts. Countries are unilaterally restrained from trade integration; also, the more central is a country the less likely it will be the target of an interstate conflict, as countries' trade integration deters other countries' willingness to entering into a conflict with that country. Similar results are found when investigating trade in oil and gas.

With concern to virtual water trade, results differ: even though the estimates derived for contiguous and proximate countries (model 1 and model 3) are generally negative, as above, but not significant, results under model 2 indicate a positive correlation among all centrality measures and the probability of conflict. For trade in virtual water, contrary to oil, it seems that the more central and integrated a country, the more likely it is to initiate a conflict and to be the target of a conflict initiated by other countries[154].

3.5.1 Evaluating Marginal Effects

Evaluating marginal effects instead of regression estimated coefficients is fundamental in order to grasp the real effect of trade on probability of conflicts, in terms of elasticity. In this respect, in this section we discuss and compare the marginal effects we have estimated.

We first analyze the marginal effect of bilateral trade and multilateral trade from the model specification related to results in Table 2, where the dataset is directed and the dependent variable (MID_NEW) account for the direction of the inter-state conflict. The aim here is again to compare the marginal effect of virtual water trade on conflicts' probability with the trade in oil and trade in footwear as well as with total trade as a baseline scenario.

We also computed marginal effects for both bilateral and multilateral trade, as well as for overlapping and import similarity indexes, as for the models whose estimated coefficients are reported in Table 3 and Table 5. We reported marginal effects results in Table 6.

Moreover, a comparison over the page rank (of both country *i* and country *j*) marginal effect has been done, and it is also reported in Table 6.

Results point out a more significant negative marginal effect of bilateral virtual water trade and oil and gas trade on conflicts' probability compared to the effect of footwear trade and total trade, if considering the full dataset (model 2). This is valid in all specifications. To quantify this effect for VW trade, it is possible to assert that a positive variation of one point percent in the ratio of VW imports from country *i* to country *j* over country *j*' GDP, decrease the chances that country *i* attacks country *j* by around 0.05 percent depending on different model specifications. Even more interesting, the marginal effect of multilateral trade variable is always significant and positive for VW trade, while it is positive (but not significant) when we consider the other categories of trade. In other words, we can say that the larger is the VW imports of country *j* from countries other than *i*, the larger is the probability that country *i* attacks country *j*. It is possible to quantify this effect in around 0.03% increase in the probability of conflicts due by a unitary increase in the percentage of multilateral imports of country *j* over its GDP.

We then move to the interpretation of the network measures. First, looking to the specification 2 in Table 6, it looks that the overlapping measure has a positive and significant estimated coefficient, which means the larger the number of VW trade neighbors country *i* and country *j* have in common, the

[154] Results are available in the web appendix.

larger is the probability that country *i* attacks country *j*. We quantify this marginal effect in a positive variation of 0.014 percent for a unitary variation of the overlapping variable. Once more, this effect is smaller when considering oil and gas trade neighbors overlapping, and even smaller in the case of total trade. Similar results are found in specification 4 in Table 6 considering import similarity index.

Considering page rank's marginal effects, results for VW trade are less strong. In fact, even if larger page rank centrality of the country *i* seems to decrease the probability of the country itself to attack country *j* and larger page rank centrality of country *j* seems to increase the probability of country *i* to attack country *j*, the estimated effects are, generally, not significant, except for total trade and oil and gas page rank of country *j*, which is significant at 10 percent (1 star) level.

TABLE 6 – Marginal effects of trade openness, overlapping, import similarity and page rank on conflicts (MID_NEW) – directed dataset

	Oil&Gas Trade		**Virtual Water Trade**		**Footwear Trade**		**Total Trade**	
VARIABLES	Model (1)	Model (2)	Model (1)	Model (2)	Model (1)	Model (2)	Model (1)	Model (2)
Specification 1								
bilateral trade openness	0.00104	-0.00177***	-0.00790	-0.000516**	0.000234	0.000133	-0.00965	-0.000849*
	(0.0130)	(0.000635)	(0.00498)	(0.000247)	(0.00172)	(0.000118)	(0.00685)	(0.000456)
multilateral trade openness	0.00179	0.000205	-0.000286	0.000286***	-0.000311	1.78e-06	-0.00130	2.30e-05
	(0.00246)	(0.000159)	(0.00142)	(0.000109)	(0.000262)	(1.45e-05)	(0.00158)	(0.000104)
Specification 2								
bilateral trade openness	0.00308	-0.00148***	-0.00857	-0.000494**	0.000501	4.93e-05	-0.0107	-0.000799*
	(0.0128)	(0.000575)	(0.00538)	(0.000237)	(0.00166)	(6.52e-05)	(0.00731)	(0.000451)
multilateral trade openness	0.00211	0.000132	-0.000120	0.000274**	-0.000199	-8.72e-06	-0.00108	1.05e-05
	(0.00274)	(0.000149)	(0.00143)	(0.000112)	(0.000226)	(8.88e-06)	(0.00176)	(0.000106)
Overlapping	-0.0110	7.33e-05*	-0.00554	0.000142***	-0.00371	-0.00478	-0.00577	8.42e-05
	(0.00800)	(4.33e-05)	(0.00684)	(4.89e-05)	(0.00381)	(0.00402)	(0.00632)	(5.87e-05)
Specification 3								
bilateral trade openness	0.00521	-0.00150***	-0.00746	-0.000544**	0.000472	5.86e-05	-0.0176	-0.000839*
	(0.0137)	(0.000575)	(0.00509)	(0.000239)	(0.00161)	(7.69e-05)	(0.0125)	(0.000436)
multilateral trade openness	0.00274	0.000179	-0.000306	0.000310***	-0.000228	-8.53e-06	-0.00194	4.89e-05
	(0.00298)	(0.000161)	(0.00162)	(0.000114)	(0.000235)	(9.78e-06)	(0.00223)	(0.000112)
Page rank_country *i*	-0.197	-0.00195	-0.0304	-0.00176	-1.264	-0.0270	0.640	-0.00284
	(0.251)	(0.00160)	(0.374)	(0.00290)	(1.690)	(0.0164)	(0.638)	(0.00390)
Page rank_country *j*	-0.188	0.00335*	-0.156	0.00398	0.0422	0.0129	0.361	0.00666*
	(0.261)	(0.00176)	(0.340)	(0.00274)	(1.539)	(0.0160)	(0.447)	(0.00397)
Specification 4								
bilateral trade openness	-0.00260	-0.00157**	-0.00827*	-0.000494**	6.74e-05	4.84e-05	-0.0104	-0.000782*
	(0.00556)	(0.000650)	(0.00497)	(0.000237)	(0.000181)	(5.44e-05)	(0.00763)	(0.000432)
multilateral trade openness	0.00141	0.000345**	-7.07e-05	0.000317***	-5.41e-06	-1.71e-06	-0.00223	3.51e-05
	(0.00152)	(0.000174)	(0.00144)	(0.000112)	(1.99e-05)	(4.80e-06)	(0.00211)	(0.000111)
Import similarity	-0.00606	0.000136	-0.0177	0.000224**	-0.00425	-0.000154	-0.00456	0.000218*
	(0.00679)	(0.000115)	(0.0150)	(0.000111)	(0.00561)	(0.000105)	(0.0207)	(0.000113)

Standard errors in parentheses
*** p<0.01, ** p<0.05, *p<0.1

Model 1: contiguous country pairs only. Model 2: full sample with interaction term and complete control set. The table does not show the controls included (number of peaceful years, UN vote correlation, number of other wars, democratic status, colonial ties, distance from nearest war, areas, membership to active alliance, contiguity, common language, existence of a free trade area, GATT membership) for space limitation.
Specification 1: directed dataset and use of MID_NEW as a dependent variable. Specification 2: Introduction of overlapping network dyad-specific measure. Specification 3: Introduction of page rank country-specific measures. Specification 4: Introduction of import similarity index.

3.6 Conclusions

We tested from an econometric point of view the relationship between interstate conflicts and control over water through the lens of international trade. The analysis has considered the impact of bilateral and multilateral trade openness on conflicts, by also taking into account heterogeneity across trade flow directions, as well as the impact of trade integration on conflicts. Following the literature on the impact of disaggregated trade on interstate conflicts, we specifically considered the following categories of trade: virtual water trade; trade in oil and gas; trade in footwear, and also compared the estimates found for each trade category with total trade as a baseline scenario. The aim was to test the strategic role of virtual water trade in international relations as compared to a traditionally widely-accepted strategic commodity such as oil and to a non-strategic commodity such as footwear.

Generally, we find strong evidence that bilateral and multilateral trade openness have opposite effects on the probability of countries to enter into conflicts. Bilateral trade openness deters countries from entering into bilateral wars, as it increases the opportunity costs of the conflict. By contrast, multilateral trade openness has the opposite effect of increasing the propensity of countries for conflicts as it increases the autonomy of countries through the opportunity of trade diversion and of finding alternative suppliers. This result hold for all categories of trade considered, i.e. total trade, trade in virtual water (food) and trade in oil and gas. These findings are generally consistent with the results from the analysis of Martin et al. (2008) concerning total trade, even though our results suggest a more enhanced deterring role for bilateral trade openness and a less pronounced role being played by multilateral trade openness. By comparing categories of trade, we also find positive evidence that virtual water trade plays a strategic role in international relations similarly to trade in oil and unlike trade in footwear.

When expanding the analysis to also include the network metrics and the other similarity indexes utilized, results generally confirm the strategic role played by virtual water trade. However, differently from Kinne (2012), we find mixed evidence that trade integration plays a deterrent role on the probability of war between country pairs and substantially reduces a country's likelihood of entering into militarized disputes.

APPENDIX 1

Estimated coefficients of trade openness on interstate conflicts (MID) – undirected dataset

	Oil&Gas Trade		**Virtual Water Trade**		**Total Trade**	
VARIABLES	Model (1)	Model (2)	Model (1)	Model (2)	Model (1)	Model (2)
bilateral trade openness	-0.030	-6.584***	-0.526**	-1.947**	-0.090***	-0.236*
	(0.816)	-2.295	(0.222)	(0.758)	(0.032)	(0.132)
multilateral trade openness	0.151*	0.088	-0.067	0.740*	0.039	1.520***
	(0.089)	(0.396)	(0.092)	(0.450)	(0.106)	(0.451)
ln distance * bilateral trade openness		0.798***		0.251***		0.038**
		(0.248)		(0.096)		(0.017)
ln distance * multilateral trade openness		-0.009		-0.099*		-0.189***
		(0.049)		(0.058)		(0.057)
Observations	3,254	105,461	3,254	105,461	7,826	223,788
Sample	Contiguous pairs	Full	Contiguous pairs	Full	Contiguous pairs	Full
Time dummies	No	Yes	No	Yes	No	Yes
Dyadic war lags	No	Yes	No	Yes	No	Yes
Dyadic same war lags	No	No	No	No	No	No
Estimation method	Logit	Logit	Logit	Logit	Logit	Logit
Pseudo R-squared	0.110	0.414	0.113	0.417	0.121	0.379

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, *p<0.1

Model 1: contiguous country pairs only. Model 2: full sample with interaction term and complete control set. The table does not show the controls included (number of peaceful years, UN vote correlation, number of other wars, democratic status, colonial ties, distance from nearest war, areas, membership to active alliance, contiguity, common language, existence of a free trade area, GATT membership) for space limitation.

APPENDIX 2

Estimated coefficients of trade openness on conflicts (MID) – directed dataset

	Oil&Gas Trade		**Virtual Water Trade**		**Footwear Trade**		**Total Trade**	
VARIABLES	Model (1)	Model (2)	Model (1)	Model (2)	Model (1)	Model (2)	Model (1)	Model (2)
bilateral trade openness	-0.245	-4.982***	-0.342**	-1.806***	0.010	0.344	-0.542**	-2.269**
	(0.614)	-1.502	(0.174)	(0.563)	(0.076)	(0.301)	(0.253)	-1.153
multilateral trade openness	0.158*	0,13125	0.026	0,2888	-0.014	0.005	-0.022	-0.120
	(0.091)	(0.419)	(0.060)	(0.289)	(0.010)	(0.037)	(0.057)	(0.318)
ln distance * bilateral trade openness		0.602***		0.233***		-0.046		0.257*
		(0.169)		(0.070)		(0.042)		(0.139)
ln distance * multilateral trade openness		-0.017		-0.056		-0.001		0.019
		(0.052)		(0.038)		(0.006)		(0.041)
Observations	6,680	213,962	6,680	213,962	6,181	200,953	6,680	213,962
Sample	Contiguous pairs	Full	Contiguous pairs	Full	Contiguous pairs	Full	Contiguous pairs	Full
Time dummies	No	Yes	No	Yes	No	Yes	No	Yes
Dyadic war lags	No	Yes	No	Yes	No	Yes	No	Yes
Dyadic same war lags	No	No	No	No	No	No	No	No
Estimation method	Logit	Logit	Logit	Logit	Logit	Logit	Logit	Logit
Pseudo R-squared	0.159	0.596	0.159	0.596	0.155	0.597	0.161	0.596

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, *p<0.1

Model 1: contiguous country pairs only. Model 2: full sample with interaction term and complete control set. The table does not show the controls included (number of peaceful years, UN vote correlation, number of other wars, democratic status, colonial ties, distance from nearest war, areas, membership to active alliance, contiguity, common language, existence of a free trade area, GATT membership) for space limitation.

Chapter 4

The Water Suitcase of Migrants

4.1 Introduction

Human migrations, dislocating food demand, impact the international trade of agricultural commodities and the food security of countries. The nexus between food, trade and human migration has been highlighted more and more frequently in the public debate. For example, the worsening of the food security situation in the Near East is not only caused by structural constraint to food production and by the increasing dependence on food imports, but by conflicts, the flow of refugees and migration (FAO, 2014). The network and dynamics of human migration have been recently and extensively studied (Abel and Sanders, 2004; Ortega, 2013) and the relation between migration and trade has also been investigated e.g. by Sgrignoli et al. (2015). However, despite the attention received by the trade-migration relationship, the nexus between human migration, food trade and water resources for food production has not been addressed yet.

The production of food requires large amounts of water: 85% of freshwater consumed by human societies is ascribable to agriculture (Mekonnen and Hoekstra, 2010). When commodities are traded, the water used for their production is virtually displaced with them, thus leading to flows of virtual water which are estimated to be 2320 m3/y, i.e, nearly 25% of the water globally consumed by humanity (Hoekstra, 2010). These numbers shed light on the great pressure of mankind on global freshwater resources and justify the increasing interest towards this form of environmental impact, usually known as water footprint, which quantifies humans' appropriation of freshwater resources.

The virtual water concept has been originally proposed by Allan (1997) basing on the observation that food import of water scarce countries implies an import of the water "embedded" in the traded commodities. Reimer (2012) gives economic foundations to the virtual water concept through the international trade theory of Heckscher-Ohlin-Vanek according to which commodity trade can be seen as an implicit exchange of the factors of production "embedded" in the commodities, in line with the interpretation of the factor content of trade accepted in international trade theory.

The virtual water trade (VWT) and the corresponding network have been investigated in a number of recent studies (Hoekstra and Hung, 2002; Lenzen, 2009; Konar et al. 2011, D'Odorico et al. 2012; Carr et al. 2013, Tamea et al. 2013). It has been highlighted that VWT can contributes to food security: (a) allowing water-scarce countries to benefit from water resources available elsewhere and to meet the food (and associated water) requirements of a growing population (Allan, 1998); (b) determining water savings at the global scale, when it provides goods with lower water footprint than they would have if produced locally; (c) determining an externalization of resources, an increase in country interdependency and a reduced resilience of society to food and water crises (Rosegrant, 2002).

What is the impact of migrants on the VWT, and how this interconnects with the water scarcity issue, is still an uncovered topic, although strongly motivated by the water- food-population nexus. Migrants strengthen commercial links among origin and destination countries (Abel, 2004), because of the persistence of alimentary habits outside the country of origin and the expected wealth improvement in the destination country. This will affect the food (and water) demand and the trade relation among countries. This paper analyzes the relation between the VWT network and the human migration network, with the aim of addressing the question on whether migrants are beneficial or detrimental to the water endowments of water scarce countries. The specific hypothesis is that an offset of water usage occurs, shifting from an agricultural use of water for locally-consumed food to a use for export towards the countries where migrants are relocated.

4.2 Results

4.2.1 The relationship between VWT and migrations

Increasing migration induces more intense trade flows, which in turn imply an increased virtual water flow out of the country of origin. To address such claim we collected data on virtual water flows and migration fluxes between all pairs of countries in the world. Migration data (M) are available for years 1990, 2000 and 2010 as stocks of migrants residing in country *j* and having birth in country *i*. Virtual water (VW) flow data are deter- mined for the same reference decades on the basis of traded quantities of three hundreds agricultural goods, converted into virtual water volumes and summed across all goods. A first clue of the relevance of migrations for determining the VW flows is provided by the correlation coefficient between the two variables, which is about 0.5 in 2010, and is visually confirmed by the scattered representation of VW flows and migration fluxes (Supplementary Material, Figure A.1). The relation between virtual water flows and migration could also derive from the dependence of the two variables on other descriptors, as correlation does not imply causation. To investigate this issue, we collected data for several explanatory variables, and applied a multivariate regression model (or gravity model).Specifically, we add controls for per capita gross domestic product (GDP), population, geographical distance between the pair, and a set of dummy variables expressing geographical contiguity, common language and common currency, colonial relationship, and the presence of a regional trade agreement, as traditionally done in the economics literature of gravity models (Anderson and Van Wincoop, 2001; Baier and Bergstrand, 2009). The wideness of the controls used in the regression, which covers economic, geographical, demographic and political aspects, aims to properly isolate the causal effect of migrants on VW trade while reducing all sources of omitted variable bias. The regression coefficients for the three decades are reported in the Supplementary Material (Table B.1) together with the variables' significance. Many variables are significant at the 0.1% level in all decades, with the regression coefficients for population and per capita GDP being in line with the literature on gravity models of commodity trade (Anderson and Van Wincoop, 2001; Baier and Bergstrand, 2009). Migrations turn out to be determinant in explaining the VW flows also in the presence of all other variables, with regression coefficients detailed in Table 1.

The key role of migration is also highlighted by the results obtained with different models, which have been used to assess the validity of such a relationship. The fixed effect (FE) specification of the gravity model, which is an effective tool based on controlling for country of origin and country of destination specific characteristics using a set of dummy variables, produces similar results in terms of migration coefficients (Supplementary Material, Table B.2). Alternative models based on count process, traditionally used to better cope with a large amount of zeros, such as Poisson, negative binomial, and zero inflated Poisson, also show positive and significant coefficients for migration, which are in line with the OLS and FE results.

Migration coefficients of gravity models are increasing in time, possibly indicating an increasing relevance of migrations. However, not being the variables normalized and given the temporal evolution of the VW trade network, a more rigorous indication is necessary to define the role of migration in explaining VW flows. To this purpose, a commonality analysis is applied to partition the variance of modeled VW flows into the contribution given by each variable in the multivariate linear regression. The analysis (results in the Supplementary Material, Table B.6) confirms the relevance of migrations in explaining VW flows across the trade network, both as a single variable and in conjunction with others, through correlation, and the increasingly relevant role of migrations in time. Furthermore, in order to remove reverse causality of migrations on VW trade flows, expressing the fact that trade connections may drive human migrations, we used an instrumental variable approach (see the Methods for details),which allowed us to confirm that causation, besides correlation, characterizes the relation between human migration and VW trade.

We also measured the effect of considering migration fluxes instead of migration stocks (see Tables B.7 and B.8 in the Supplementary Materials for more details). The effect of migration fluxes on the VW trade is still positive and significant, but lower in magnitude compared to stocks. Also refugees and asylum-seekers migrants are considered, but they do not have a significant effect on VW fluxes (see Tables B.12 and B.13 in the Supplementary Material).

4.2.2 The water suitcase of migrants

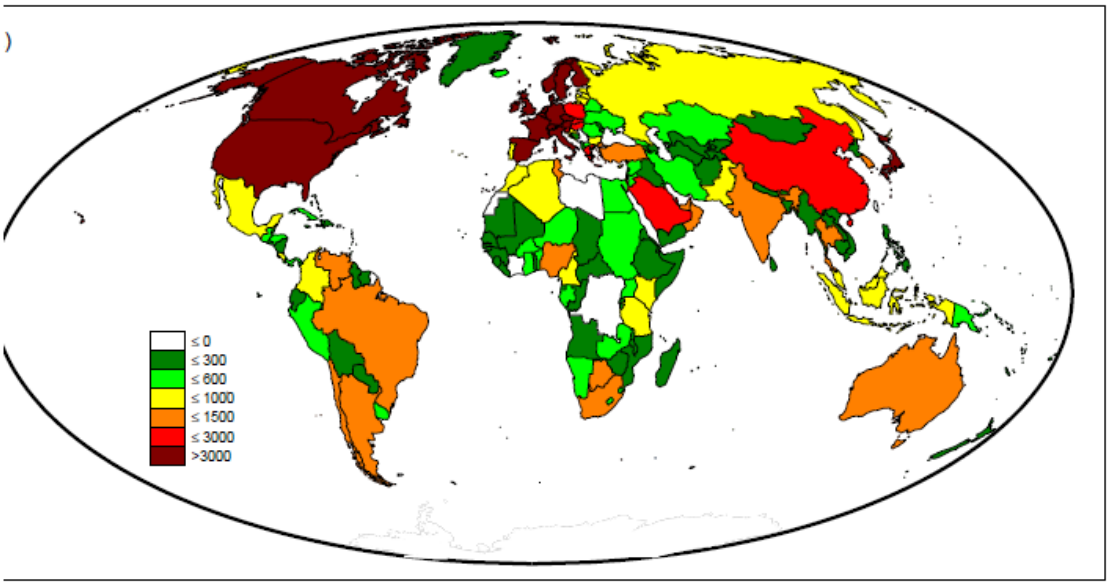
The gravity model allows one to quantify the volume of virtual water exchanged worldwide as driven by a unit increase of human migration. This volume is a sort of *water suitcase* associated to each migrant, as it represents the amount of water that an additional migrant is virtually carrying from his/her origin country to his/her destination country, due to more intense trade flows with the motherland induced by migrant communities.

The global average suitcase increases from 233 m3 per capita per year in 1990 to 1367 m3 per capita per year in 2010 with a tendency to double for every decade (Table 1). The evolution towards larger water suitcase and the increasing number of migrants worldwide suggests an overall expansion of the total volume of virtual water associated to (and driven by) migration. Such increase is, likely, justified by the overall increase of virtual water volumes exchanged worldwide (Hoekstra and Mekonnen, 2012) and by the increasing role of migration in determining trade.

Table 1: Post-significance estimated coefficients and Water Suitcase of migrants

Measure	1990	2000	2010
Migration estimated coefficient	0.098	0.185	0.306
Average suitcase of migrants [m^3/p/y]	233.47	696.73	1366.7

In order to characterize the geography of virtual water suitcases by country, one may focus on outgoing fluxes and define the water suitcase of emigrants, *S out*, quantifying the country-specific virtual water export associated to each person who left the country and lives abroad. The map of emigrant suitcases in 2010 and their temporal variations from 1990 to 2010 are shown in Figure 1. Likewise, a country-specific suitcase of immigrants can be defined using virtual water imports, but it appears less relevant for the considerations that follow (map in the Supplementary Material, Figure A.2).



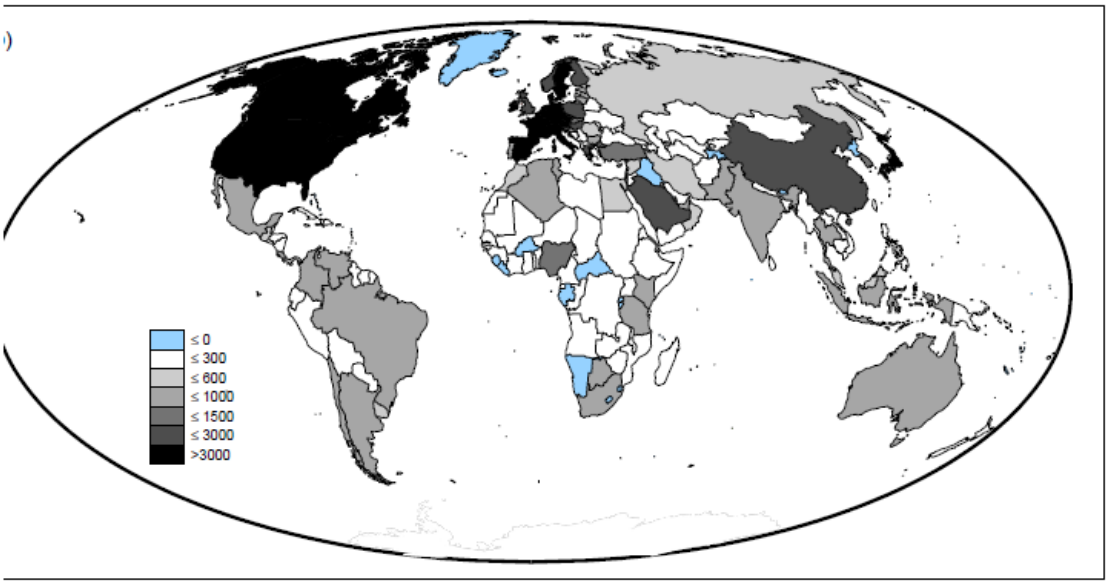


Figure 1: World map of the VW suitcase of emigrants in 2010 (a) and of the suitcase variations from 1990 to 2010 (b); suitcases are measured in m3/p/y.

People leaving North American and Central European countries have a larger suitcase, likely depending on the advanced socio-economic conditions and living standards of emigrants from these countries and their capability of inducing trade when moving abroad. The virtual water suitcase of emigrants, in fact, appears to be correlated to the socio-economical wealth of the country of origin, with the correlation coefficient between the suitcase and the per-capita GDP being 0.325 in 1990 and 0.527 in 2010. People from major Asian countries (except for Japan and China) have a small suitcase when leaving their home countries, similarly to some Central African and Near East regions.

Temporal trends are investigated by taking the difference between the suitcase of emigrants in the 2010 and in the 1990 decade. The map of differences confirms and details the marked increase anticipated above for global values. The overall trend from 1990 to 2010 is clear. Countries already having large outgoing suitcases in 1990, such as North American and European countries, have further increased the suitcase values. Emerging economies are those showing very high increase from 1990 to 2010; examples include China, Turkey, Brazil, Argentina and Australia, while African countries maintain their heterogeneity still showing a clear increasing pattern. Cases without VW increases involve countries with limited export (e.g., New Zealand, Mongolia, Kazakhstan) or undergoing economic and political crises in the period examined (e.g., Afghanistan, Iraq, Somalia and Central African Republic).

4.2.3 The water footprint of migrations

We now consider the specific impact of migration on the water resources of home countries, with the aim of addressing the question: *Are migrants relieving the pressure on local water resources when migrating out of the country of origin?* To address this question, we employ the per-capita water footprint (WF) of consumption, that is the virtual water content of all goods consumed within an area divided by the population in the area. Averaging over the period 1996-2005, Hoekstra and Mekonnen (2010) found a global average of 1385 m3/y per capita, and highly heterogeneous values among different countries.

The water footprints of migrants in origin and destination countries are first calculated and compared. To this purpose, migration stocks are multiplied by the per-capita water footprint of people in the two countries and summed up over all migration links worldwide. Table 2 summarizes these results, showing that the overall WF of migrants reached a volume of 400 km3/y in 2010; the volume has being growing in the last decades due to the increase in the number of migrating people.

Table 2: Water footprint of migrants in origin and destination countries

WF of migrants [in km^3/y]	1990	2000	2010
In origin countries	144.5	231.3	304.3
In destination countries	180.6	288.0	399.5
Difference	+36.1	+56.7	+95.2

The overall WF in destination countries is always larger than in the home countries, likely due to the fact that larger migration fluxes occur from poorer to richer countries (Abel 2004), thus (likely, although not systematically) from countries having a lower per-capita water footprint to countries with higher per-capita water footprint. Therefore migration is likely to enhance the pressure on global water resources. The difference between the two rows in Table 2 represents the impact of migration on global water resources (i.e., the water footprint increase due to migrations), which grows in time from 36 to 95 km3/y, at a more-than-proportional rate than migration. Although being approximations not accounting for relevant factors, such as the socio-economic conditions of immigrants in destination countries and their rapidity of adaptation to local diets, these volumes give an indicative measure of the increase of virtual water consumption associated to migration.

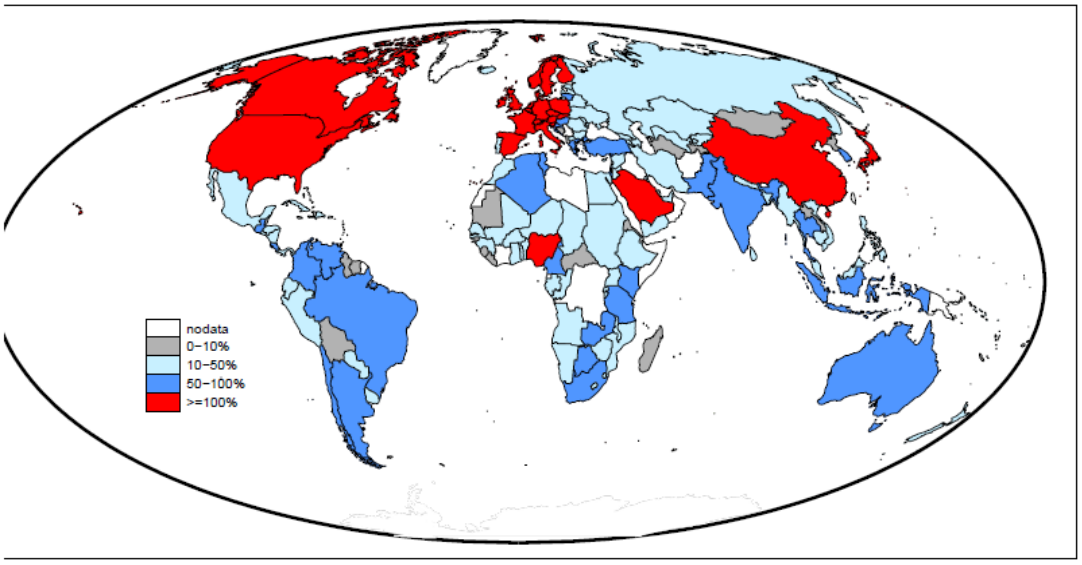


Figure 2: Ratio (in percentage) of the VW suitcase of emigrants over the water footprint of inhabitants in each country, in decade 2010, quantifying the water pressure relieved (in red) or increased (in blue) by the departure of each emigrant.

The virtual water suitcase of emigrants from each country is, then, compared to the per-capita water footprint in the countries of origin, taken from Mekonnen and Hoekstra (2010). The percentage ratio between the two variables is represented in Figure 2, as an attempt to quantify the relief in the water pressure within a specific country implied by the emigration of a person in such country.

These results give a view of which countries benefit from expatriation phenomena in terms of water pressure relief, and which ones detriment. In most countries the virtual water suitcase of emigrants is lower or comparable to the water footprint of inhabitants of such countries, while in few countries (North America, most of Europe, Saudi Arabia, Nigeria, China and Japan) the virtual water suitcase of emigrants is larger than the water footprint of inhabitants. In these cases, emigrants are further depleting the water resources of their own countries to meet the virtual water demand associated

to migration-induced trade. A comparison with the relief in the water pressure in 2000,for which we used the same per-capita water footprint from Mekonnen and Hoekstra (2010), (Supplementary Material, Figure A.3) shows an average increase of the relief in the water pressure, in the last decade. In particular, in China, Saudi Arabia and Nigeria, as well as in the south of Europe (Italy and Spain), the suitcases of emigrants were smaller than the footprint in 2000, while turned out to be higher in 2010. Most Asian and African water stressed countries also increased their relief values, giving a confirmation of the increasing role played by migrants in affecting the countries' water pressures.

4.2.4 The network of relieves

We investigate more in depth the countries where the VW suitcase of emigrants is higher than the VW footprints of inhabitants, using network analysis techniques. For each pair of countries where a flux of VW and migrants is active, we calculate the relief associated to such link as the difference between the water footprint in the origin country and the water suitcase of emigrants, multiplied by the number of migrants on that link.

We consider only the links where the relief is negative, i.e. migrations are detrimental to the water resources of origin countries. Results in the left chart of Figure 3 use nodes' dimensions to identify country's centrality and the different colors of nodes to represent communities according to the Newman-Girvan community detection algorithm. Evidences found in Figure 2 are confirmed: USA, China and Central European countries are the most central regions in the network, meaning that emigrants from those countries have a bigger suitcase (relative to footprint) when moving towards several destinations. Comparison with the network in 2000 also highlights an evident increase in the number of country pairs with a negative water relief. Emerging countries, such as India and China, are now more central in the network, and water scarce countries such as Tunisia and Morocco also appear in the network, although as a destination, rather than an origin, country.

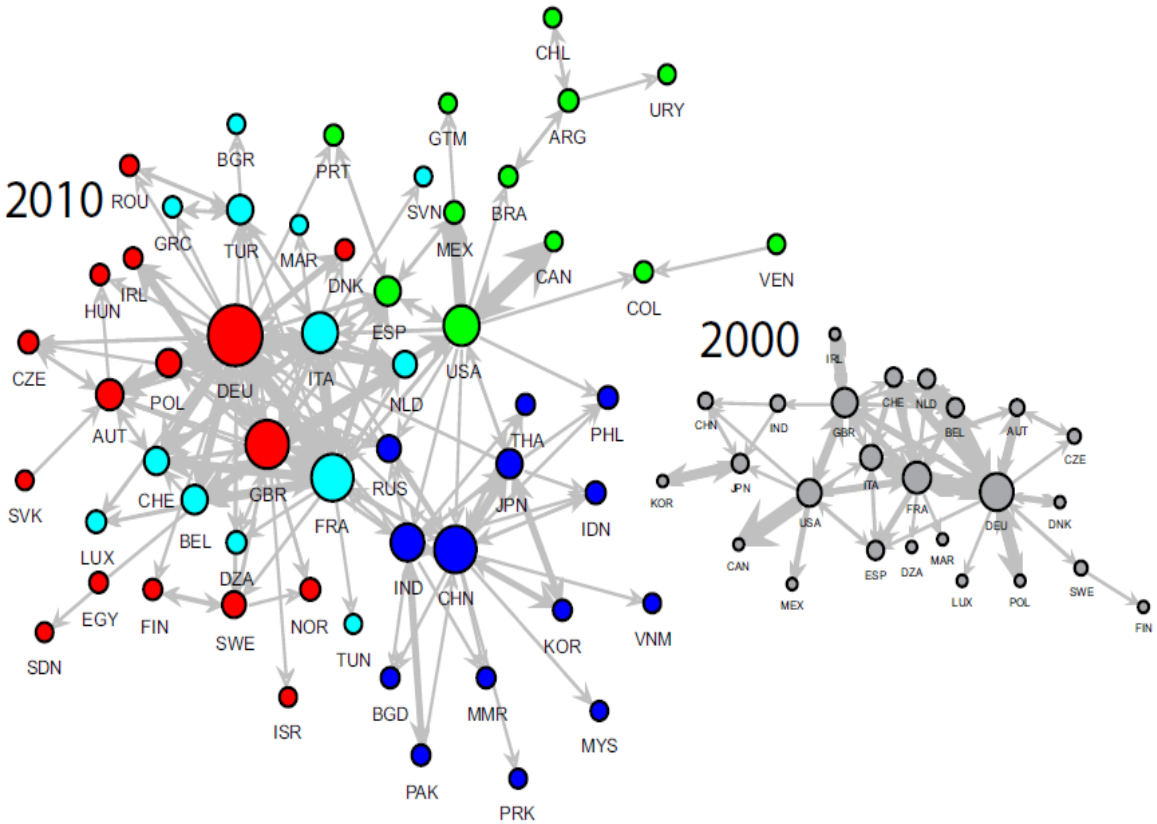


Figure 3: Network structure representing the country pairs (nodes) where we find a negative relief (links) in 2010 (2000 in the inset).

4.3 Conclusions

Virtual water trade provides water-scarce countries a chance to minimize internal water use by increasing imports from water-rich countries, thus alleviating water scarcity problems through global economic processes such as import of food products. Yet, currently the global water savings envisaged in virtual water trade analyses is only happening to a limited extent: Hoekstra (2010) finds that international trade is reducing global water-use in agriculture by 5 %; Costinot et al. (2012) find that trade in agricultural products mainly conforms to the rules of comparative cost advantages in such factors as labor, land, and capital.

In recent empirical works, it is said that the movement of production factors (migrants) across borders can provide an increase in the movement of traded goods, and this phenomenon is even more empathic for VW trade, triggering the discussion on how to correctly define its causes, and its possible policy implications.

We have added here the human-migration dimension to such analyses, investigating whether migrants from water-scarce countries are beneficial or detrimental to water endowments of their motherland. We have thus measured the volume of the additional virtual water flow out of the countries of origin as associated to each migrant (the water suitcase of migrants), and compared it to the water footprint of origin countries. Overall, we find that the relief in water pressure associated to migration is heterogeneous over countries and reduced over time. In some cases the expatriation- induced trade is so much relevant to induce a detrimental effect of migrations on the water resources of the motherland.

Countries should adopt appropriate policies aimed at reducing such virtual water flows, especially when detrimental to the water endowments of severely water-scarce countries. For instance, host and origin countries could co-operate in implementing policies to enhance the role that return migrants can play to reduce the water footprint of food production in their countries of origin, for example allowing for increased transfer of technologies and production methods to the countries of origin. Giving importance to the role of institutions in avoiding a global earth catastrophe, host countries could play a role for enhancing migrants exposure to (and learning of) water-efficient production technologies and methods, as well as access to technologies for reducing water losses from leakages in the infrastructure and reservoirs or for improving waste water treatments. Countries of origin could facilitate the application of these technologies from the return migrants, providing for example targeted incentives. Such actions may contribute to reduce the water footprint of domestic production in the countries of origin, as well as reducing the water suitcase of the successive migrants.

Materials and Methods

Data

The analysis focuses on human migration (M) data taken from the United Nation database (2013). Such data express the stock of migrants born in country of birth *i* and living into country of residence *j*; data are available for every decade from 1960 to 2010, and for year 2013; we use here data for years 1990, 2000, and 2010, as they overlap with available trade data.

Virtual water trade (VWT) data are reconstructed basing on the data from Food and Agricultural Organization of the United Nations, Statistics Division (Faostat), for the international trade of 309 agricultural commodities exchanged from country of origin *i* to country of destination *j*. Annual values are known from 1986 to 2010 and data are then averaged over the years 1986-1990, 1991-2000 and 2001-2010 to match migration data. Trade data are then converted into virtual water flows by multiplying for the virtual water content of each commodity, as provided by the global assessment of Mekonnen and Hoekstra (2010). Elaboration and characterization of data is detailed in Carr et al. (2013) and Tamea et al. (2013).

Other variables involved in the analysis include the *population,* and the *per capita GDP* in USD, *xgdp*, of all countries over the considered period (1986 to 2010). Data are extracted from the United

Nations Statistics Division - National Accounts Main Aggregates Database. Annual data are averaged over the years 1986-1990, 1991-2000 and 2001-2010.

In addition, a series of bilateral geographic and economic variables are used as extracted from the "Geodist" CEPII database. Variables include the distance between each pair of countries, weighted by the population distribution within the countries, and a series of binary dummies, namely *contiguity* (equal to 1 if the pair shares a common border), *common currency* (equal to 1 if the pair shares the currency), *common language* (equal to 1 if the pair has the same official language), *colony* (equal to 1 if one of the two countries is a colony of the other), *regional trade agreements* (equal to 1 if the two countries share some regional free trade agreement), *tariff and trade agreements,* equal to 1 if the given country belong to the World Trade Organization (WTO). The weighted distance does not depend on time, while dummy variables are taken for the three cross sections (1990, 2000 and 2010).

After data cleaning and matching, the number of links wherein both virtual water and migration data are available, and the regression can thus be established, changes from decade to decade and equals 5959 (in 1990), 8874 (in 2000) and 9261 (in 2010).

The gravity model

Gravity models are extensively used in International Economics to explain trade fluxes. The generalized expression of a gravity model recalls the law of universal gravitation which, after log-transforming all variables, can be managed as a multivariate linear regression. Common proxies for origin and destination size are measures of a country's economic and market dimension such as income level, population, area size and per capita gross domestic product (GDP). Here we used population as a country size and per capita GDP to control for the country richness. A variety of impedance factors have been also incorporated aiming at examining potential barriers or incentives to trade flows. Typically encountered factors of that kind are common language, common currency and contiguity, since it is expected that these factors may promote trade between countries.

In our application we include the classical gravity variables and dummies, besides colony, regional agreements and tariff and trade agreements.

$$\widehat{VW}_{ij} = 10^{b_0} \cdot M_{ij}^{b_1} \cdot x_{gdp,i}^{b_2} \cdot x_{gdp,j}^{b_3} \cdot x_{p,i}^{b_4} \cdot x_{p,j}^{b_5} \cdot x_{d,ij}^{b_6} \cdot 10\text{^}(b_7 \cdot x_{c,ij} + b_8 \cdot x_{cl,ij} + b_9 \cdot x_{col,ij} + b_{10} \cdot x_{cc,ij} + \ldots$$

$$+ b_{11} \cdot x_{rta,ij} + b_{12} \cdot x_{tta,i} + b_{13} \cdot x_{tta,j}$$

The multivariate regression coefficients, estimated with the ordinary least square method, are shown in the Supplementary Material (Table B.1). Subsequently, coefficients undergo a t-Student test to verify if they are significantly different than zero, in order to check the significance of each variable in the regression. After selecting only the variables which satisfy the test at the 0.1% level, the regression is re-run with only significant regressors, and the new estimated coefficients are used to calculate the suitcases.

Alternative models

The ordinary least squares (OLS) method has traditionally been used for estimating the coefficients of the baseline gravity specification in its log-linear form. While the baseline gravity equation is commonly used in empirical analysis, multilateral trade constraints may be taken into account. According to Baier and Bergstrand (2007), a simply way of treating multilateral constraints is the use of a fixed effect (FE) model. This model specification consists of including origin- and destination-specific countries' intercepts in the regression. This approach includes the effect of cross-country variations of explanatory variables but precludes the analysis of country-specific determinants, we thus employ the FE model using origin-based and destination-based country fixed effects dropping country-specific variables.

$$\widehat{VW}_{ij} = 10^{\alpha_i} \cdot 10^{\alpha_j} \cdot M_{ij}^{a_1} \cdot x_{d,ij}^{a_2} \cdot 10\text{^}(a_3 \cdot x_{c,ij} + a_4 \cdot x_{cl,ij} + a_5 \cdot x_{col,ij} + a_6 \cdot x_{cc,ij} + a_7 \cdot x_{rta,ij})$$

The migration regression coefficient takes values comparable with the baseline model, with a larger difference in 1990; the fitting capabilities measured by the coefficient of determination (R2) are not comparable between the OLS and FE models due to the larger number of fitted parameters in the FE formulation (all α's values).

Other models are used as a check for results robustness: in particular we apply the Poisson and the Negative Binomial (NegBin) models, the zero-inflated Poisson (ZIP) and zero-inflated Negative Binomial (ZINB). Poisson and NegBin are valid alternatives to OLS, which are based on considering the dependent variable as a count process, thus removing the assumption of normal distribution and enabling the accounting of high share of zero flows. The zero inflated models consists, instead, of a two-steps procedure. In the first step, we estimate the probability of existence of a link between two countries (at least one m3 of VW) with a probit regression. In the second step we estimate the value of VW with a Poisson or NegBin model, conditional to the first step. In particular, the ZIP permits to obtain consistent estimates even when big amount of zeros are present; ZINB further accounts for over-dispersion on the distribution of the data, assuming that the generator process for the VWT distribution is of a count type.

In the Supplementary Material (Table B.3) we reported the coefficient results for the decade 2000, using all the different models tested for this diagnostic process. Column 1 reports the baseline OLS results, column 2 the Poisson results, column 3 the NegBin, column 4 ZIP and column 5 ZINB. The overdispersion parameter θ of the zero inflated models is positive and significant, which plays in favor of the zero inflated compared with the simple Poisson or NegBin models. The Migration coefficients are slightly higher than in the baseline gravity, reaching a maximum of 0.327 in the negative binomial specification. However, the fitting of the non-linear models (in terms of comparison between real and fitted VW values) is worse than the baseline counterpart.

All of the alternative models show positive and significant coefficients for migration, which are in line with the OLS and FE results.

Diagnostic tools

- VW trade versus commodity trade

Other checks have been done in order to collect additional information about the relevance of migration for the virtual water trade. First, we performed a gravity model using economical values of commodity trade as dependent variables and the same explanatory variables. We did this robustness checks for the decade 2000 using bilateral trade flow data from NBER-UN dataset described by Feenstra et al. (2001). The trade model presents a significantly lower migration coefficients compared to VW, and we found that the migration coefficient equals 0.185 (using baseline) and 0.282 (considering FE model) with the trade counterpart.

- Homogeneous links

Secondly, since the number of active links changes over time, we consider whether the increase in the magnitude of the migration coefficient is due to a real increase in the migration impact, or to a change in the number and types of links. To do so, we compare the coefficients obtained standardizing the data sample, thus using only links that are active throughout the three decades. It emerges that the increase in the migration coefficient from 1990 to 2010 is partly due (11.0% for the OLS model) to an increase in the number of links. The remaining part is motivated by the evolution in the VW-migration relation. Tables B.5 in the Supplementary Material provides all the coefficient results.

- **Commonality analysis**

Considering a multivariate regression between a dependent variable Y and a set of regressors *x1,x2,x3*, ..., the variance of Y can be expressed partly by the contribution of each regressor alone (unique contribution), and partly by the join contribution of other regressors, exerted through regressor correlation. In order to identify the contribution of each regressor and disentangle the role of correlation, a commonality analysis is performed. This is a statistical tool to determine the partitioning of variance into the contribution given by each regressor into a multivariate linear regression. Table B.6 in the Supplementary Material shows that the magnitude is affected by the part conjointly explained by the other explanatories in the model. The commonality coefficients report a common value that increases over time (from 0.202 in 1990 to 0.325 in 2010) and a unique value of 0.003 for 1990, that increases at 0.010 for the 2000 cross section and 0.025 for year 2010.

- **Different types of commodities**

Virtual water fluxes are associated with the trade of different commodities which can be organized in four main categories, namely: crops, luxury food, animal-based and non- edible products (see Carr et al. 2013 and Tamea et al. 2013). We analysed, by means of the gravity model and the FE specification, the effect of migrations on the VW trade associated to each category, showing that all of them are positively affected by migrants. The effect of migration is higher for VW trade associated to crops and animal-based commodities, while migrants have less importance in explaining VW trade associated to non-edible commodities. Model coefficients (Supplementary Material, Table B.4) show an increasing temporal trend similarly to the trend found in the overall model, considering all categories (Supplementary Material, Tables B.1 and B.2)

- **Migration flows data**

It may be argued that the effect of migrants moving in a certain period (migration flows) can be significant, in place of migration stocks. However, we suspect a temporal delay between the migrants settlement and trade initiation/intensification thus we expect the effect of stocks to be higher. To check for this hypothesis, we used two different sources of data. First, we constructed migration flows data for each pair of countries and each direction from stock data, by taking the differences between subsequent decades; occasional negative values are set to 0. Then, we used a more accurate migration flow database, built by Abel and Sanders (2004) from the same UN stocks data, but accounting for births and deaths rates. They estimated and published migration flows for the periods 1990-1995, 1995-2000, 2000-2005, 2005-2010; in order to match the decades of our analysis, we summed up the corresponding 5-years flows. We re-runned the OLS and the FE models for the two decades (Supplementary Material, Tables B.7 and B.8), using both our differenced UN data and Abel-Sanders data. Results highlight that also migration flows significantly affect the VW fluxes, but to a smaller extent compared to stocks.

- **Instrumental variable approach**

We used the instrumental variable approach to overcome the issues of potential re- verse causality of migration and VW trade. Several approaches have been proposed to remove the effect of spurious correlations using an instrumental variable. We adopt the two stage least square method, were, at the first stage, a regression is set between the migration flows (endogenous) and the time-lagged migration flows. At the second step, we use the fitted values of the first step as a exogenous migration variable in the instrumented regression. Looking at the migration coefficients in the instrumented regression (Supplementary material, Table B.10) compared with the same (non-instrumented) coefficients (Supplementary material, Tables B.7 and B.8), it is possible to see that results are robust to different method specifications, proving that the role of reverse causality in the VW trade-migrants relations is marginal.

- **The role of refugees and asylum seekers**

An asylum seeker is defined as someone who leaves its own country, often for political reasons or because of war, and who travels to another country hoping that the government will protect him/her and allow him/her to live there. A refugee is an asylum seeker who obtained the permission to live in the destination country. These migrants usually leave countries undergoing a crisis (political or socio-economic) which are unlikely to be able to increase VW trade. To check this hypothesis we perform the OLS and the FE gravity models for the decades 1990-2000 and for 2000-2010, replacing total migration flows with refugees and asylum seekers flows. We used data from UNHCR Population Statistics Database (2013), which reports information on refugees flows for every year for the period 2000-2013, where asylum seekers are taken as the people applying for asylum during the year, and the number of total decisions is taken as a proxy for the number of refugees.

Results (Supplementary Material, Tables B.12 and B.13) show a non-significant effect of both refugees and asylum seeker on VW trade. Therefore, it is possible to argue that VW flows changes are not affected by the flow of forced migrants, such as asylum seekers or refugees. On the contrary, they are guided by the flow of those migrants that, with their alimentary habits, drive a change in VW flows.

The virtual water suitcase of migrants

The gravity model describes the fluxes of virtual water associated to international trade among pairs of countries as a function of socio-economic regressors. Considering the regression model utilized, the variation of virtual water flux (between countries i and j) associated to a variation of migration can be evaluated with a Taylor expansion to the first order around actual conditions and reads:

$$\delta\widehat{VW} = b_1 \cdot \frac{\widehat{VW}}{M} \cdot \delta M.$$

Averaging the above expression over all links having both a virtual water exchange and a non-null migration, the overall variation of virtual water flux per unit variation of migration, S, reads:

$$S = \frac{1}{M_{tot}} \sum_{w=1}^{n} M_w \left. \frac{\delta\widehat{VW}}{\delta M} \right|_w = b_1 \cdot \frac{\widehat{VW}_{tot}}{M_{tot}}$$

where n is the number of links considered for the average, $\widehat{VW}_{tot}$ is the sum of all modeled virtual water fluxes and M_{tot} is the total number of migrants. Variable S represents the volume of virtual water exchanged worldwide as driven by a unitary increase of migration thus associated to each migrant as a sort of virtual water suitcase of migrants.

In order to characterize the geography of virtual water suitcases, the sum can be limited to the links involving one single country at a time. A differentiation should then be made between incoming fluxes and outgoing fluxes, defining a virtual water import per immigrant, S_{in}, and a virtual water export per emigrant, S_{out}, which read:

$$S_{in} = b_1 \cdot \frac{\sum_{w=1}^{n_{in}} \widehat{VW}_{import}}{\sum_{w=1}^{n_{in}} M_{in}}, S_{out} = b_1 \cdot \frac{\sum_{w=1}^{n_{out}} \widehat{VW}_{export}}{\sum_{w=1}^{n_{out}} M_{out}}$$

respectively. The former quantifies the country-specific virtual water import associated to each foreigner living within the country and the latter quantifies the country-specific virtual water export associated to each person who left the country and lives abroad.

Supplementary Materials

A Relation between migration and VWT

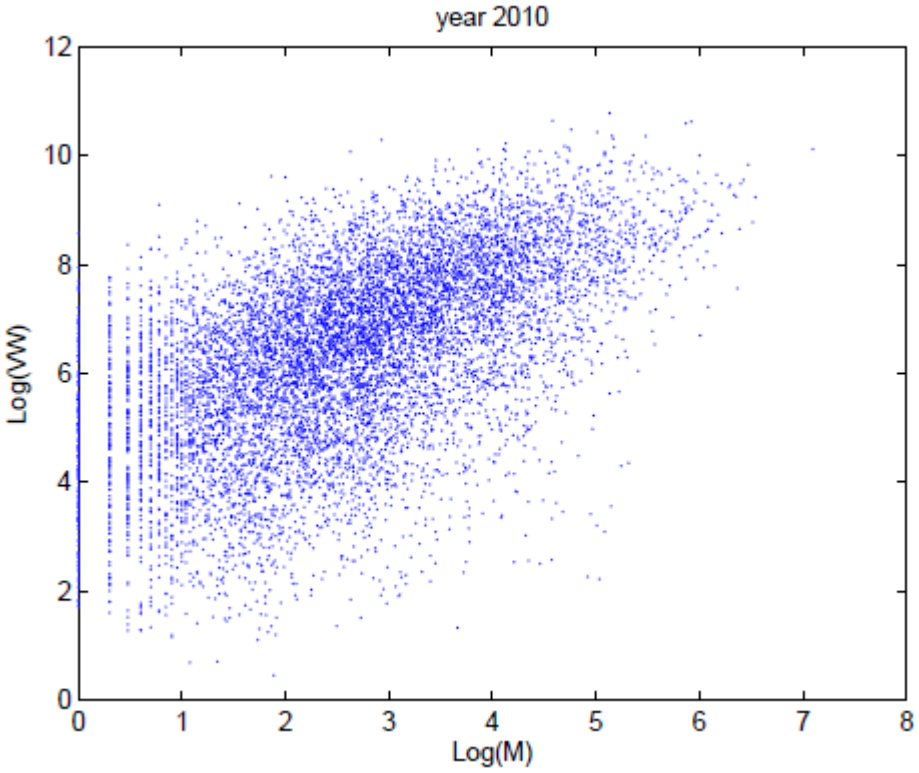


Figure A.1: Scatter plot between VW flows and migrations fluxes (2010).

A.1 Water suitcase and water relief

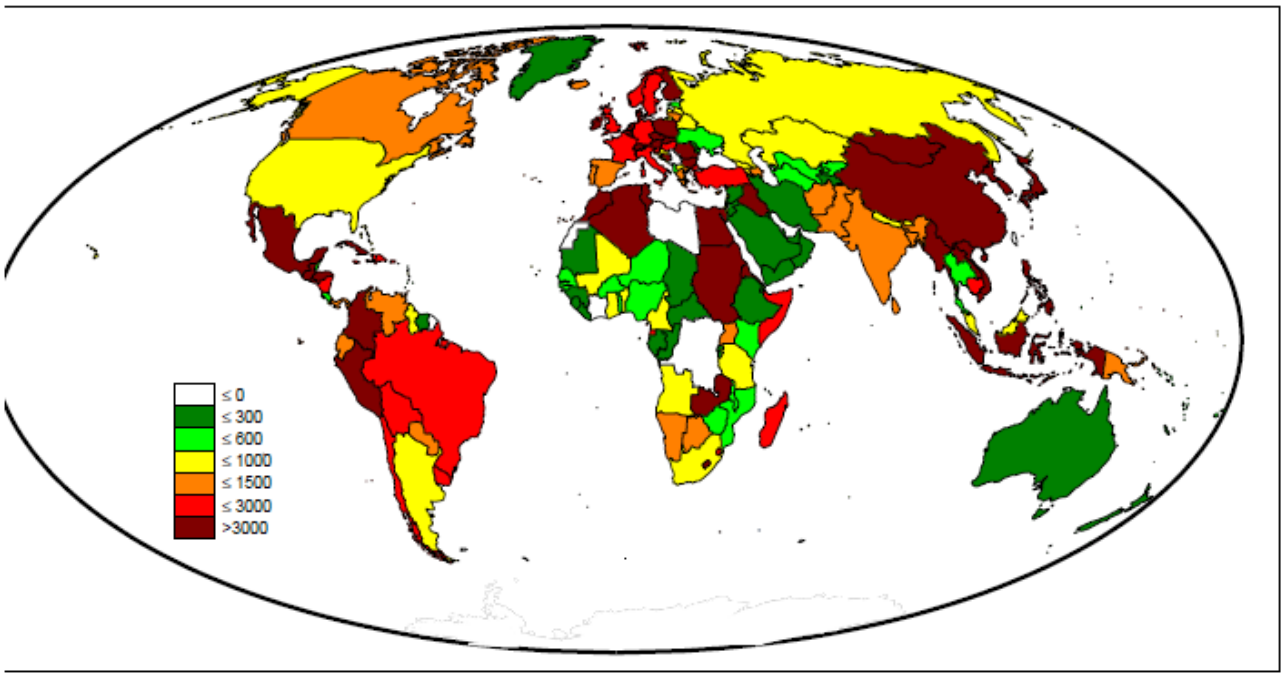


Figure A.2: World map of the VW suitcase of immigrants in 2010 (in m3 per capita per year).

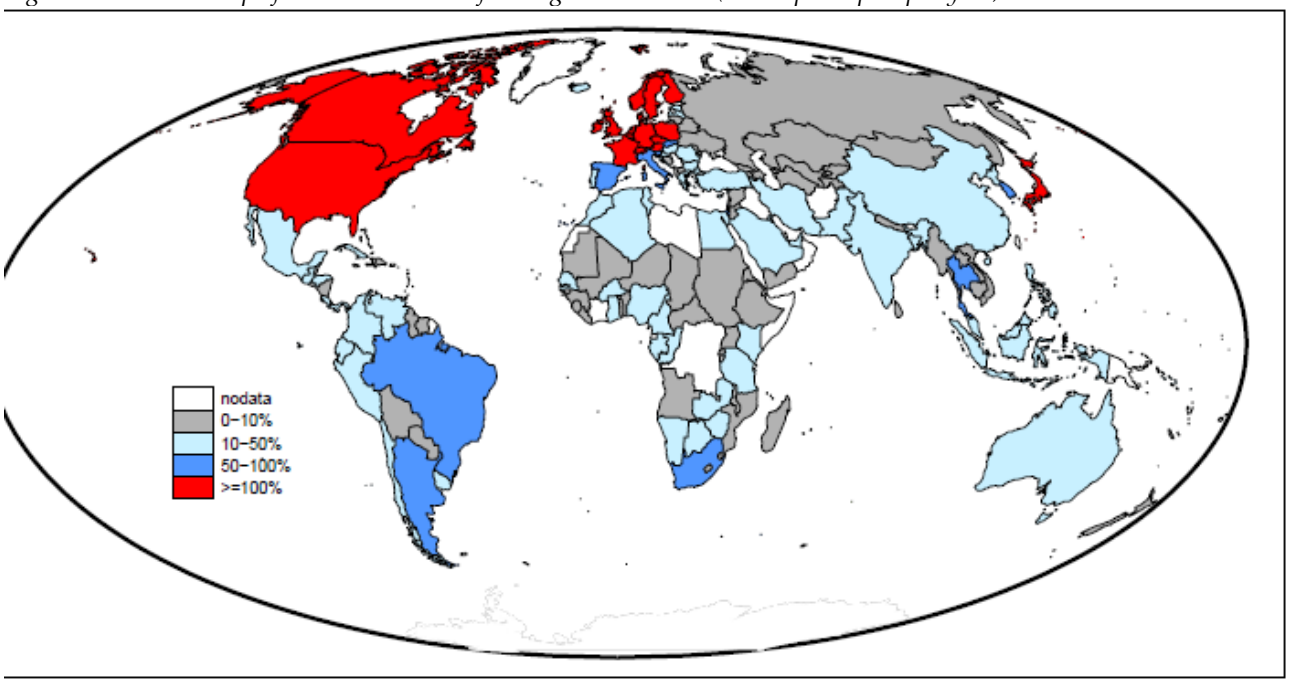


Figure A.3: World map of the Ratio (%) of the VW suitcase of emigrants over the water footprint of inhabitants in 2000 (in m3 per capita per year).

B Gravity model results

B.1 Alternative method results

Table B.1: Coefficients of the gravity model describing the VW flows, estimated with OLS. Asterisks indicate the level of significance. ('.' $p < 0.1$, '' $p < 0.05$, '**' $p < 0.01$, '***' $p < 0.001$)*

Decade	1990	2000	2010
migration	0.099^{***}	0.185^{***}	0.305^{***}
weighted distance	-0.748^{***}	-0.862^{***}	-0.881^{***}
population (o)	0.658^{***}	0.836^{***}	0.824^{***}
population (d)	0.729^{***}	0.681^{***}	0.658^{***}
per capita GDP (o)	0.384^{***}	0.486^{***}	0.402^{***}
per capita GDP (d)	0.650^{***}	0.558^{***}	0.370^{***}
contiguity	0.267^{**}	0.297^{***}	0.298^{***}
common language	0.168^{***}	0.190^{***}	0.263^{***}
colony	0.577^{***}	0.469^{***}	0.316^{***}
common currency	0.440^{*}	-0.140	0.134
regional trade agreements	0.095	0.183^{***}	0.282^{***}
tariff and trade agreements (o)	0.315^{***}	0.443^{***}	0.258^{***}
tariff and trade agreements (d)	-0.090	0.003	-0.188^{***}
N. observations	5959	8874	9261
R^2-adjusted	0.359	0.454	0.483

Table B.2: Gravity model results, using the fixed effect (FE) formulation ('.' p < 0.1, '' p < 0.05, '**' p < 0.01, '***' p < 0.001)*

decade	**1990**	**2000**	**2010**
migration	0.198***	0.273***	0.298***
weighted distance	-0.844***	-1.016***	-1.070***
contiguity	0.187***	0.238***	0.242***
common language	0.150***	0.131***	0.202***
colony	0.430***	0.422***	0.345***
common currency	0.604***	-0.351***	-0.022
regional trade agreements	-0.118	-0.085***	0.151***
tariff and trade agreements(o)	1.263***	1.756***	1.463***
tariff and trade agreements(d)	-0.512	-0.199	0.115
N. observations	5945	8860	9247

Table B.3: Gravity model results: comparison with alternative methods ('.' p < 0.1, ''p < 0.05, '**' p < 0.01, '***' p < 0.001)*

specification	**baseline**	**poisson**	**NegBin**	**ZIP (2^{nd} step)**	**ZINB (2^{nd} step)**
migration	0.185***	0.237***	0.327***	0.227***	0.264***
weighted distance	-0.862***	-1.037***	-0.984***	-1.011***	-0.775***
population(o)	0.836***	1.262***	1.361***	1.215***	1.175***
population(d)	0.681***	1.078***	1.291***	1.046***	1.165***
per capita GDP(o)	0.486***	0.663***	1.009***	0.637***	0.830***
per capita GDP(d)	0.558***	0.723***	1.100***	0.712***	0.930***
contiguity	0.297***	0.332***	0.697***	0.328***	0.717***
common language	0.190***	0.306***	0.213**	0.314***	0.252***
colony	0.469***	0.083***	0.589***	0.106***	0.485***
common currency	-0.140	0.258***	-0.381*	0.271***	-0.269*
regional trade agreements	0.183***	0.042***	0.243*	-0.573***	0.196**
tariff and trade agreements(o)	0.444***	0.826***	0.378***	0.772***	0.303***
tariff and trade agreements(d)	0.0025	-0.858***	0.150	-0.151***	-0.011
θ(disp.)	-	-	0.115***	-	0.273***
N. observations	8874	11233	11233	11233	11233

Table B.4: Gravity model results for the main categories ('.' p < 0.1, '' p < 0.05, '**'p < 0.01, '***' p < 0.001)*

	1990	2000	2010
VW in crops - OLS	0.186***	0.210***	0.345***
VW in animal-based products - OLS	0.165***	0.140***	0.197***
VW in luxury food - OLS	0.045***	0.132***	0.216***
VW in non-edible products - OLS	-0.124***	-0.079***	-0.059***
VW in crops - FE	0.240***	0.309***	0.344***
VW in animal-based products - FE	0.241***	0.247***	0.179***
VW in luxury food - FE	0.189***	0.285***	0.280**
VW in non-edible products- FE	0.103***	0.149***	0.175***

B.2 Role of active links' temporal variability

Table B.5: Gravity model results (OLS method) using homogeneous links ('.' $p < 0.1$, '' $p < 0.05$, '**' $p < 0.01$, '***' $p < 0.001$)*

type	homog links		
decade	1990	2000	2010
migration	0.105***	0.131***	0.283***
weighted distance	-0.776***	-0.780***	-0.683***
population(o)	0.638***	0.729	0.689***
population(d)	0.711***	0.676***	0.637***
per capita GDP(o)	0.414***	0.400***	0.267***
per capita GDP(d)	0.679***	0.474***	0.251***
contiguity	0.283**	0.334***	0.280***
common language	0.162**	0.25***	0.290***
colony	0.545***	0.374***	0.206**
common currency	0.391*	0.186*	0.315***
regional trade agreements	0.002	0.065	0.244***
tariff and trade agreements(o)	0.296***	0.573***	0.421***
tariff and trade agreements(d)	-0.081	-0.003	-0.213**
N. observations	5162	5162	5162
R^2-adjusted	0.349	0.433	0.456

B.3 Commonality

Table B.6: Commonality coefficients for the baseline model (OLS method).

decade	1990		2000		2010	
coefficient	unique	total	Unique	total	unique	total
migration	0.003	0.202	0.010	0.260	0.025	0.325
weighted distance	0.021	0.026	0.024	0.026	0.021	0.058
population (o)	0.072	0.074	0.118	0.129	0.102	0.125
population (d)	0.089	0.099	0.071	0.074	0.063	0.083
per capita GDP (o)	0.020	0.012	0.036	0.026	0.022	0.017
per capita GDP (d)	0.038	0.007	0.032	0.007	0.012	0.001
contiguity	0.001	0.021	0.001	0.029	0.001	0.049
common language	0.002	0.000	0.002	0.001	0.003	0.002
colony	0.006	0.019	0.003	0.022	0.001	0.021
common currency	0.000	0.000	0.000	0.002	0.000	0.008
regional trade agreements	0.000	0.020	0.001	0.048	0.003	0.061
tariff and trade agreements (o)	0.007	0.029	0.011	0.024	0.003	0.008
tariff and trade agreements (d)	0.000	0.010	0.000	0.001	0.001	0.000

B.4 Migration flows data

Table B.7: Regression results for the decade 1990-2000, using flows of migration instead of migration stocks. i) OLS with our flows, ii) FE with our flows, iii) OLS with Abel-Sanders flows, iv) FE with Abel-Sanders flows.

	i	ii	iii	iv
migration	0.027 ***	/	0.106 ***	/
migration_ abel	/	0.043***	/	0.087 ***
weighted distance	-1.017 ***	-0.880 ***	-1.076 ***	-1.175 ***
population (o)	0.916 ***	0.915 ***	/	/
population (d)	0.820 ***	0.797 ***	/	/
per capita GDP (o)	0.527 ***	0.564 ***	/	/
per capita GDP (d)	0.626 ***	0.738 ***	/	/
contiguity	0.373 ***	0.462 ***	0.186 **	0.278 ***
common language	0.290 ***	0.290 ***	0.156 ***	0.273 ***
colony	0.552 ***	0.518 ***	0.470***	0.425 ***
common currency	-0.131	-0.017	-0.129	-0.229 **
regional trade agreements	0.206 ***	0.171 ***	-0.072	-0.167 ***
tariff and trade agreements (o)	0.410 ***	0.447 ***	1.789 ***	1.654 ***
tariff and trade agreements (d)	-0.153 ***	-0.100 *	0.020	1.182
N. observations	8428	8879	8428	8879
R^2-adjusted	0.443	0.431	0.685	0.661

Table B.8: Regression results for the decade 2000-2010, using flows of migration instead of migration stocks. i) OLS with our flows, ii) FE with our flows, iii) OLS with Abel-Sanders flows, iv) FE with Abel-Sanders flows.

	i	ii	iii	iv
migration	0.047 ***	/	0.040 ***	/
migration_ abel	/	0.082 ***	/	0.079 ***
weighted distance	-1.164 ***	-0.916 ***	-1.408 ***	-1.351 ***
population (o)	0.964 ***	0.926 ***	/	/
population (d)	0.811 ***	0.787 ***	/	/
per capita GDP (o)	0.471 ***	0.511 ***	/	/
per capita GDP (d)	0.518 ***	0.567 ***	/	/
contiguity	0.454 ***	0.512 ***	0.351 ***	0.310 ***
common language	0.402***	0.381 ***	0.301 ***	0.303 ***
colony	0.457 ***	0.377 ***	0.508 ***	0.422 ***
common currency	0.025	-0.102	-0.071	-0.187 *
regional trade agreements	0.318 ***	0.268 ***	-0.117	0.058
tariff and trade agreements (o)	0.328 ***	0.482 ***	1.511 ***	1.086 ***
tariff and trade agreements (d)	-0.278 ***	-0.129 *	0.493	-0.211
N. observations	8764	8228	8764	8228
R^2-adjusted	0.459	0.455	0.694	0.679

Table B.9: Commonality coefficients for the baseline model (OLS method), using migration flows. i) 1990-2000, our flows, ii) 1990-2000, Abel-Sanders flows, iii) 2000-2010, our flows, iv) 2000-2010, Abel-Sanders Flows.

	i		ii		iii		I	
	Unique	**Total**	**Unique**	**Total**	**Unique**	**Total**	**Unique**	**Total**
migration	0.001	0.026	0.001	0.033	0.001	0.025	0.001	0.035
weighted distance	0.000	0.005	0.000	0.005	0.000	0.006	0.000	0.006
population (o)	0.015	0.011	0.013	0.011	0.015	0.013	0.013	0.013
population (d)	0.018	0.016	0.015	0.016	0.020	0.020	0.018	0.020
per capita GDP (o)	0.010	0.011	0.010	0.011	0.009	0.008	0.009	0.008
per capita GDP (d)	0.009	0.007	0.010	0.007	0.006	0.002	0.006	0.002
contiguity	0.014	0.027	0.013	0.027	0.019	0.035	0.018	0.035
common language	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
colony	0.000	0.002	0.000	0.002	0.000	0.001	0.000	0.001
regional trade agreements	0.001	0.017	0.001	0.017	0.001	0.016	0.001	0.016
common currency	0.010	0.023	0.010	0.023	0.009	0.021	0.009	0.021
tariff and trade agreements (o)	0.000	0.003	0.000	0.003	0.000	0.003	0.000	0.003
tariff and trade agreements (d)	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.000

B.5 Instrumental variable approach

Table B.10: Regression results for 2000-2010, using two stage least square (2SLS) instrumental variable approach with time lagged migration flow as instrument. i) OLS, our flows, ii) FE, our flows, iii) OLS, Abel-Sanders flows, iv) FE, Abel-Sanders Flows.

	i	**ii**	**iii**	**iv**
migration	0.052 ***	0.050 ***	/	/
migration_abel	/	/	0.051 ***	0.102 ***
weighted distance	-0.751 ***	-1.408 ***	-0.738 ***	-1.420 ***
population (o)	0.800 ***	/	0.785 ***	/
population (d)	0.677 ***	/	0.672 ***	/
per capita GDP (o)	0.258 ***	/	0.268 ***	/
per capita GDP (d)	0.403 ***	/	0.400 ***	/
contiguity	0.558 ***	0.336 ***	0.506 ***	0.298 ***
common language	0.310 ***	0.306 ***	0.314 ***	0.316 ***
colony	0.296 ***	0.522 ***	0.323 ***	0.415 ***
common currency	0.131	-0.082	0.147	-0.220 **
regional trade agreements	0.183	*** 0.119	** 0.208 ***	0.054
tariff and trade agreements (o)	0.359 ***	1.507 ***	0.364 ***	1.181 ***
tariff and trade agreements (d)	-0.124 ***	0.177	-0.100 ***	-0.179
N. observations	8.413	8.413	7.917	7.917
R^2-adjusted	0.456	0.695	0.450	0.679

Table B.11: Diagnostic tests for the lagged migration flow variable as instrument. First Stage F-test for instrument relevance and Wu-Hausman F-test for esogeneity.

	i		**Ii**	
	Coeff	p-val	coeff	p-val
First Stage F-test	5 047.551	0.000	3 372.277	0.000
Wu-Hausman F-test	27.469	0.000	8.928	0.000

B.6 Role of asylum seekers and refugees

Table B.12: Regression results for the effect of Refugees /asylum seekers on VW trade. 2000-2005. i) OLS, refugees, ii) FE, refugees, iii) OLS, asylum seekers, iv) FE, asylum seekers

	i	**ii**	**iii**	**iv**
refugees	-0.105 ***	-0.017	/	/
asylum seekers	/	/	-0.066 ***	0.002
weighted distance	-1.029 ***	-1.592 ***	-1.040 ***	-1.589 ***
population (o)	1.019 ***	/	1.021 ***	/
population(d)	0.858 ***	/	0.859 ***	/
per capita GDP (o)	0.460 ***	/	0.458 ***	/
per capita GDP (d)	0.694 ***	/	0.700 ***	/
contiguity	0.690 ***	0.521 ***	0.681 ***	0.518 ***
common language	0.398 ***	0.370 ***	0.397 ***	0.370 ***
colony	0.591 ***	0.595 ***	0.587 ***	0.592 ***
common currency	-0.070	-0.249 **	-0.077	-0.245 **
regional trade agreements	0.327 ***	0.104 **	0.333 ***	0.105 **
tariff and trade agreements (o)	0.300 ***	1.114 ***	0.303 ***	1.129 ***
tariff and trade agreements (d)	-0.013	0.356 *	-0.011	0.357 *
N. observations	6413	6413	6222	6222
R^2-adjusted	0.418	0.615	0.418	0.615

Table B.13: Regression results for the effect of Refugees /asylum seekers on VW trade, 2005-2010. i) OLS, refugees, ii) FE, refugees, iii) OLS, asylum seekers, iv) FE, asylum seekers.

	i	**ii**	**iii**	**iv**
refugees	-0.093***	0.003	/	/
asylum seekers	/	/	-0.074 ***	0.018
weighted distance	-1.026***	-1.653***	-1.042 ***	-1.645 ***
population (o)	1.050***	/	1.056 ***	/
population (d)	0.834***	/	0.839 ***	/
per capita GDP (o)	0.458***	/	0.451 ***	/
per capita GDP (d)	0.670***	/	0.681 ***	/
contiguity	0.743***	0.500***	0.743 ***	0.494 ***
common language	0.449***	0.393***	0.450 ***	0.391 ***
colony	0.519***	0.560***	0.524 ***	0.556 ***
common currency	-0.075	-0.174*	-0.086	-0.167 *
regional trade agreements	0.464***	0.290***	0.465 ***	0.294 ***
tariff and trade agreements (o)	0.301***	0.578***	0.304 ***	0.592 ***
tariff and trade agreements (d)	-0.018	0.104	-0.014	0.103
N. observations	6670	6670	6518	6518
R^2-adjusted	0.418	0.622	0.418	0.622

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