

VIRTUAL WATER FLOWS IN BELARUS-CHINA BILATERAL TRADE OF AGRICULTURAL PRODUCTS

Summary. *In this paper we used data on volumes of agricultural trade between Belarus and China as well data on water requirements for each crop and animal product traded between the two countries to calculate virtual water flows associated with agricultural products in Belarus-China bilateral trade. During 2014-2017 the outflow of virtual water associated with crop and animal products from Belarus to China accounted for 389,6 million m³, while the outflow of virtual water from China to Belarus was about 313,3 million m³. Due to Belarus's comparative advantage in water trade and China's growing water scarcity, the present state of Belarus-China virtual water trade is advantageous for both countries and helps to relieve water stress in China.*

Key words: *virtual water, Belarus-China trade, water stress, agricultural trade.*

Problem statement. As the global water shortage problem is becoming more severe and widespread, more scientists are concerned about the water usage and global water flows. Traditionally, trade between countries was measured using countries' imports and exports values. But there is one relatively new concept that allows to measure trade through the water flows embodied in international trade – it's called the concept of virtual water. The previous research on trade between Belarus and China was mostly conducted from the

economic and political perspective, but there was no research on the virtual water flows embodied in the bilateral trade between Belarus and China. In this study, we measure the virtual water flows related to trade of agricultural products between the Republic of Belarus and the People's Republic of China as well as determine whether the trade of agricultural products between the two countries contributes to national and global water saving.

Analysis. The concept "virtual water" was first described by Allan (1993, 1994) in the beginning of the 1990's and stands for the amount of water needed to produce a good or service. It was introduced as a result of research on ways to alleviate water by importing more water-intensive goods. Virtual water flows are calculated by multiplying the amount of trade of agricultural products by their specific water content:

$$VWF=CT*VWC \quad (1)$$

where VWF stands for virtual water flow from exporting country (m³), CT is commodity trade volume (tons), and VWC is virtual water content (m³).

Bilateral agricultural trade data in this study comes from The International Trade Centre (ITC). The data was collected manually for each product at the six-digit level. The water footprint coefficients for crop and animal products come from the Value of Water Research Report Series by Mekonnen and Hoekstra (2010). In a case when there was no water footprint coefficient for a certain product produced in a certain country, and we were sure that the country produces it, the data for the water footprint coefficient was taken from a country similar in geographical and economic conditions. For Belarus we chose Ukraine, and for China we used India.

In addition to these two datasets for each country, we use the data on water availability and water withdrawal from National Water Footprint Accounts, UNESCO-IHE by Mekonnen & Hoekstra (2011), World Development Indicators, The World Bank.

By using water requirements for each product (different for each product and with regard to the place of production) traded between Belarus and China and the data on the volumes of agricultural trade, we calculated the virtual water flows between the two countries. It is agreed that bottom-up approach is a suitable method for calculation of virtual water flows associated with agricultural products. However, in the future works we suggest using some kind of combined approach that would capture the advantages and avoid the drawbacks of both general types of methods.

The calculation results show that there is an upward trend of virtual water content in bilateral trade in crop and animal products. The total bilateral virtual water flows have increased by 167% from 2010 to 2017. Belarus's exports of virtual water to China increased from 36,822,872 m³ in 2010 to 93,771,268 m³ in 2017, while China's virtual water exports to Belarus have seen an increase from 39,782,576 m³ in 2010 to 110,961,690 m³ in 2017.

Table 1

Virtual water flows related to agricultural products between Belarus and China in 2010-2017, m³

Year	Belarus's exports to China	China's exports to Belarus
2010	36 822 872	39 782 576
2011	30 364 110	48 241 615
2012	21 953 175	42 268 693
2013	30 534 238	44 864 545
2014	58 273 797	13 227 266
2015	122 235 710	104 192 289
2016	115 281 263	84 898 341
2017	93 771 268	110 961 690

Below are the lists of Top 10 products at the six-digit level for both countries by their associated virtual water flow in 2014-2017. China's virtual water exports to Belarus are much more diversified. We can observe that the

differences between values of virtual water volume associated with products on the Top 10 products list are much less extreme than those of Belarus and there are no such big outliers in the Top 10 products list. In addition, there are no animal products on China’s list of Top 10 exports to Belarus.

Table 2

Virtual water flow associated with Belarus’s Top 10 agricultural exports to China in 2014-2017, m³

Product code	Product name	Total virtual water, m3
530129	Flax fibre, otherwise processed but not spun	239 634 986
530121	Flax fibre, broken or scutched	66 839 358
151411	Low erucic acid rape or colza oil, crude	25 809 672
410792	Grain splits leather of the portions	10 647 585
40490	Products consisting of natural milk constituents	9 430 015
510100	Wool, fine or coarse animal hair	8 702 451
230240	Bran, sharps and other residues of cereals	8 428 733
110813	Potato starch	6 660 796
40221	Milk and cream powder unsweetened	4 305 721
40120	Milk not concentrated & unsweetened	2 363 416

Table 3

Virtual water flow associated with China’s Top 10 agricultural exports to Belarus in 2014-2017, m³

Product code	Product name	Total virtual water, m3
071080	Vegetables, frozen nes	46 733 384
080810	Apples, fresh	38 666 659
520800	Woven fabrics of cotton	27 792 563
190190	Malt extract; food preparations of flour, groats, meal, starch	27 766 118
081120	Raspberries,mulberries, frozen	22 034 412
081190	Frozen fruit and nuts, uncooked or cooked	18 711 950
071022	Beans, frozen	13 597 080
230990	Preparations of a kind used in animal feeding	12 826 633

520600	Cotton yarn	10 611 924
080540	Grapefruit, fresh or dried	7 979 250

Some interesting findings are related to the analysis of virtual water trade by water type. Since different water types have different opportunity costs, it is important to distinguish between them while assessing bilateral trade. It was found that the grey and blue water share in China's agricultural exports to Belarus is much higher than that of Belarus to China. It means that China is exporting a bigger share of much more "valuable" types of water, while Belarus is exporting more of the less "valuable" green water.

Table 4

Shares of green, blue, and grey virtual water types in bilateral trade

	2014	2015	2016	2017	Average share of water type, %
Belarus's exports to China					
Green	48 517 717	101 567 408	94 814 988	77 380 082	82,8%
Blue	182 909	309 546	411 329	692 020	0,4%
Grey	9 573 170	20 358 756	20 054 946	15 699 165	16,8%
China's exports to Belarus					
Green	8 882 507	65 687 737	50 101 410	63 424 104	61,6%
Blue	1 177 942	5 632 923	5 746 125	11 504 711	7,9%
Grey	3 166 817	32 871 629	29 050 807	36 032 875	30,5%

Moving on to the water requirements, we found that Belarus's biggest agricultural exports have much higher values of water requirements than the Chinese agricultural exports to Belarus. For instance, Belarus's average green water requirements for Top 10 exports to China are about 4700 m³ per ton of product, while green water requirements for China's exports to Belarus are about 700 m³ per ton. There are similar differences for grey water as well. However, the blue water requirement for Belarus's exports to China is almost

two times lower than that of China's exports to Belarus, 81 m³ per ton and 188 m³ per ton respectively.

By comparing water requirements for the same product in the exporting country and the importing country we can determine whether the trade in virtual water is beneficial for global water savings. Average green water requirement for Belarus's Top 10 agricultural exports is 4700 m³ per ton. At the same time, in China, the importing country, it would require only half of that amount of water, or about 2800 m³ per ton, to produce the same products. Top 10 Belarus's exports to China, however, require much less blue water if they are produced in Belarus than if they were produced in China. Finally, the grey water requirements for Belarus's Top 10 agricultural exports to China are much higher in the exporting country compared to those in the importing country: 814 m³ per ton compared to 402 m³ per ton respectively. In case with China, green, blue, and grey water requirements for the exported products are much higher than they would be if the products were produced in Belarus. This means that both Belarus and China by exporting their agricultural products do not facilitate global water savings. If Belarus domestically produced agricultural products it imports from China and if China domestically produced products it imports from Belarus, virtual water use would be more efficient from the global perspective.

However, examining virtual water trade volumes would not be representative without taking into consideration the water availability in both countries. Belarus has 34 billion m³ of internal renewable freshwater resources, while China possesses 2813 billion m³ of internal renewable freshwater resources, however, per capita numbers are less optimistic: 3589 m³ and 2062 m³ in Belarus and China respectively. Water withdrawals make the situation even more severe: in 2014 Belarus reported 5% annual freshwater withdrawals (as % of internal water resources), while for China this number was 21,6%. Similarly, the water stress level estimated by the World Bank's World

Development Indicators (annual water withdrawals as a share of the renewable resources) is 4,54% for Belarus and 29,38% for China.

Taking into consideration all the facts mentioned above, we conclude that Belarus is a much more water rich country than China, therefore, it has a comparative advantage in exporting water intensive goods to China, while China is a relatively water poor country (and it is going to become even more poor in the years to come) and does not possess a comparative advantage in exporting virtual water to Belarus.

Conclusions. To summarize, we believe that the present state of Belarus-China virtual water trade associated with agricultural products is mutually beneficial. Moreover, the trends we noticed while analyzing bilateral virtual water trade during the years 2014-2017 will facilitate sustainable development for both countries in the future by providing an opportunity for Belarus to utilize its comparative advantage in water intensive goods trade, while allowing China to preserve its limited water resources and alleviate the water scarcity to some extent by exporting less water intensive products to Belarus. In the future works we consider using an improved method for calculating virtual water embodied in bilateral trade which will combine the bottom-up and the top-down approaches. The findings might be considered in trade policy making and will be useful for better water management in Belarus, China as well as other countries with similar virtual water trade profile.

References

1. Allan, J.A. Virtual water: A Long Term Solution for Water Short Middle Eastern Economies. British Association Festival of Science, University of Leeds, 1997.
2. Allan, J.A. Virtual water: A strategic resource global solutions to regional deficits. *Ground Water*, 1998, 36(4): 545–546.

3. Chapagain, A.K. Globalisation of water opportunities and threats of virtual water trade, [PhD Dissertation]. UNESCO-IHE Institute, Delft, 2004. Sourced from: Research Gate.
4. Chapagain, A.K., Hoekstra, A.Y. The global component of freshwater demand and supply: an assessment of virtual water flows between nations as a result of trade in agricultural and industrial products. *Water International*, 2008, 33(1): 19–32.
5. Chapagain, A.K., Hoekstra, A.Y. *Water International* The global component of freshwater demand and supply: an assessment of virtual water flows between nations as a result of trade in agricultural and industrial products. *Water International*, 2008. 33 (1): 0–0.
6. Hoekstra, A.Y. Virtual water trade. Proceedings of the International Expert Meeting on Virtual Water Trade. IHE Delft, The Netherlands, Value of Water, Research Report Series No. 12, 2003.
7. Hoekstra, A.Y. Water neutral: reducing and offsetting the impacts of water footprints. *The Value of Water Research Report Series No. 28*, 2008.
8. Hoekstra, A.Y., Mekonnen, M.M. The water footprint of humanity. *Proceedings of the National Academy of Sciences*, 2012, 109 (9): 3232-3237.
9. Jiang, W., Marggraf, R. Bilateral virtual water trade in agricultural products: a case study of Germany and China. *Water International*, 2015, 40(3): 483-498.
10. Lamastra, L., Miglietta, P.P., Toma, P., De Leo, F., Massari, S. Virtual water trade of agri-food products: Evidence from Italian-Chinese relations. *Science of the Total Environment*, 2017, 599–600: 474–482.
11. Lee, S.H., Yoo, S.H., Choi, J.Y., Mohtar, R.H. Evaluation of external virtual water export and dependency through crop trade: an Asian case study. *The International Society of Paddy and Water Environment Engineering and Springer Japan*, 2016.

12. Shtull-Trauring, E., Bernstein, N. Virtual water flows and water-footprint of agricultural crop production import and export: A case study for Israel. *Science of the Total Environment*, 2018, 622–623: 1438–1447.
13. Zhang, Y., Zhang, J.H., Tian, Q., Liu, Z.H., Zhang, H.L. Virtual water trade of agricultural products: A new perspective to explore the Belt and Road. *Science of the Total Environment*, 2018, 622–623: 988–996.