Economic sciences

UDC 327+339.5

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DOI: 10.25313/2520-2057-2019-4-4795

# 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 as 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 the period from 2014 to 2017, the outflow of virtual water associated with crop and animal products from Belarus to China accounted for 389,6 million* $m^3$*, while the outflow of virtual water from China to Belarus was about 313,3 million* $m^3$*. 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:

$$VWF=CT*VWC \tag{1}$$

where VWF stands for virtual water flow from exporting country ($m^3$), CT is commodity trade volume (tons), and VWC is virtual water content ($m^3$).

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 $m^3$ in 2010 to 93,771,268 $m^3$ in 2017, while China's virtual water exports to Belarus have seen an increase from 39,782,576 $m^3$ in 2010 to 110,961,690 $m^3$ in 2017.

*Table 1*

**Virtual water flows related to agricultural products between Belarus and China in 2010-2017, $m^3$**

| 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, $m^3$**

| 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, $m^3$**

| 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 $m^3$ per ton of product, while green water requirements for China's exports to Belarus are about 700 $m^3$ 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 $m^3$ per ton and 188 $m^3$ per ton respectively.

By comparing water requirements for the same product in the exporting country and the importing county 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 $m^3$ per ton. At the same time, in China, the importing country, it would require only half of that amount of water, or about 2800 $m^3$ 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 $m^3$ per ton compared to 402 $m^3$ 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 $m^3$ of internal renewable freshwater resources, while China possesses 2813 billion $m^3$ of internal renewable freshwater resources, however, per capita numbers are less optimistic: 3589 $m^3$ and 2062

$m^3$ 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 profiles.

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