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Virtual water trade of agricultural products: A new perspective to explore the Belt and Road

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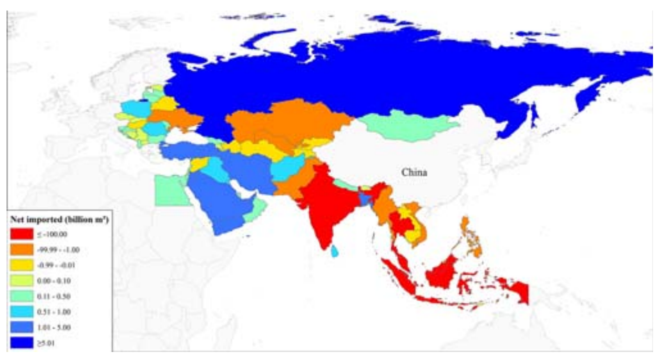
HIGHLIGHTS

- Virtual water is a new perspective to explore the Belt and Road.
- China was in virtual water trade surplus with the countries along the Belt and Road.
- >40 countries had a virtual water trade surplus with China.
- The proportion of the grey water footprint that China exported to the spanning countries was much higher than that imported.
- Virtual water trade with China benefits both the countries along the Belt and Road and China.

GRAPHICAL ABSTRACT



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ABSTRACT

The Belt and Road is an initiative of cooperation and development that was proposed by China. Moreover, most of the spanning countries faced water shortages and agriculture consumed a lot of water. Virtual water links water, food and trade and is an effective tool to ease water shortages. Therefore, this paper aims to understand the Belt and Road from the new perspective of virtual water trade of agricultural products. We considered agricultural products trade from 2001 to 2015. On the whole, the results indicated that China was in virtual water trade surplus with the countries along the Belt and Road. However, in terms of each country, >40 spanning countries were in virtual water trade surplus with China and eased water shortages. Russia had the largest net imported virtual water from China. Furthermore, the proportion of the grey water footprint that China exported to the spanning countries was much higher than that imported, no matter from the whole or different geographical regions. Moreover, more than half of the countries' virtual water trade with China conformed to the virtual water strategy, which helped to ease water crises. Furthermore, the products that they exported to China were mainly advantageous products that each spanning countries have. Virtual water trade is a new perspective to explore the Belt and Road. Agricultural products trade with China definitely benefits both the countries along the Belt and Road and China from the perspective of virtual water. The findings are beneficial for the water management of the countries along the Belt and Road and China, alleviating water shortages, encouraging the rational allocation of water resources in the various departments. They can provide references for optimizing trade structures as well.

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1. Introduction

Currently, the world faces serious water shortages. In 2014, renewable internal freshwater resources per capita in the world were 5925.67 m^3, where in 1962, they were 13,360.32 m^3 (The World Bank, 2016c). This represents a decrease of almost 1500 m^3 every ten years. Appreciating the global dimension of freshwater resources can be regarded as a key to solving some of today's most urgent water problems (Hoekstra et al., 2011). In addition, according to the report published by United Nations World Water Assessment Programme (WWAP) in 2015, from a global point, groundwater provides around 50% of all drinking water and 43% of all agricultural irrigation (WWAP, 2015). With the growing population, more water will be needed to produce the estimated 60% of extra food needed by 2050 (Food and Agriculture Organization of the United Nations, 2017). Agriculture is the important department that consumes much water. Agricultural water use is an indispensable part in alleviating the global water crises and re-allocating the global water. However, it is not just a technological problem, it needs to be considered from a more comprehensive and higher scales, not only visible water, but virtual water; not only regional level, but global scale.

Virtual water and water footprint were conceived as effective tools to address the water crisis. The concept of 'virtual water', established by Tony Allan (Allan, 1993), refers to the water used in the production of any commodity. In 2002, Hoekstra put forward the concept of a water footprint (Hoekstra and Hung, 2002), which aims to measure the water content of all goods and services consumed by one individual or by the individuals of one country (Hoekstra, 2003). It includes green water footprint, blue water footprint and grey water footprint. The green water footprint refers to the rainwater consumed in the production of a good, the blue water footprint refers to the surface and groundwater consumed (evaporated), and the grey water footprint denotes the water pollution, which is the volume of freshwater that is required to assimilate the load of pollutants based on existing ambient water quality standards (Mekonnen and Hoekstra, 2010a). Both virtual water and water footprint are used to estimate the water content in a product or service. The main difference of the two concepts is that virtual water is defined from the perspective of production while the water footprint is defined from a consumption point of view (Velázquez et al., 2009). When referring to the trade, the concept of virtual water is usually used (Chapagain et al., 2006a; Dalin et al., 2012; Zeitoun et al., 2010). When any such commodity is traded, the production water 'embedded' in the product may also be considered 'traded' (Zeitoun et al., 2010). When the product is exchanged through international trade, virtual water "flow" takes place (Novo et al., 2009). Then, virtual water trade takes place as the volume of water embedded in the products exchanged internationally (Duarte et al., 2014). Virtual water trade has relevant environmental and socio-economic implications (Tamea et al., 2016). The most direct positive effect of virtual water trade is the water savings it generates in the countries or the regions that import the products. Countries can save water through the import of water-intensive products or to make use of relative water abundance to produce water-intensive commodities for export. This effect has been widely discussed in virtual water studies since the nineties (Allan, 1999).

Global trade in agricultural products has grown rapidly in recent decades and is expected to continue to increase in the next few decades. Considering the large share of water withdrawal for food production, a growing number of literature about virtual water trade of agricultural products can be currently available (Chen and Chen, 2013). From the global aspect, Hoekstra and Hung characterized the globalization of water resources associated with international crop trade (Hoekstra and Hung, 2005). Chapagain et al. analysed the consequences of international virtual water flows on the global and national water budgets by calculating 285 crop products and 123 livestock products, which covers international trade between 243 countries for 1997–2001 (Chapagain et al., 2006a). Then Mekonnen and Hoekstra further discussed the water footprint of agricultural products by disguising the green, blue and grey water footprint in a spatially-explicit way for the period 1996–2005. According to the above data, they estimated international virtual water flows, finding that trade in crop products contributes 76% to the total volume of international virtual water flows; trade in animal and industrial products contribute 12% each (Mekonnen and Hoekstra, 2010a; Mekonnen and Hoekstra, 2010b; Mekonnen and Hoekstra, 2011). Chen and Chen applied a multi-region input-output model to investigate the virtual water profile of the world in 2004 (Chen and Chen, 2013). Evolution of the global virtual water trade network has also been estimated in association with global food trade (Dalin et al., 2012). In addition, there were also researches on national and regional virtual water flows of agricultural products, such as Nile Basin (Zeitoun et al., 2010), EU river basins (Vanham, 2013), Intra-EU (Antonelli et al., 2017), Spain (Novo et al., 2009), Libya (Wheida and Verhoeven, 2007), China (Dalin et al., 2014; Zhang et al., 2016), China and Italy (Lamastra et al., 2017).

China is one of the world's major agricultural producers and exporters, and is an important consumer of agricultural products as well (Ministry of Commerce of the People's Republic of China, 2015; Xiong and Deng, 2014). It is of great significance for global trade patterns and food security. Moreover, in line with the change in domestic and international relations, new reforms and opening-up strategies arose, and "The Belt and Road" was proposed by Chinese President Xi Jinping in 2013 during visits to Kazakhstan and Indonesia (Lin, 2015). "The Belt and Road" refers to "the Silk Road Economic Belt and the 21st-Century Maritime Silk Road". It aims to establish a regional cooperative framework from east to west, across Asia to Africa and Europe, based on the core concepts of peace, cooperation, development and win-win solutions. It is a means of win-win cooperation that promotes common development and prosperity. Through "policy coordination, facilities connectivity, unimpeded trade, financial integration and people-to-people bond", it works to build "a community of common interest, destiny and responsibility" (National Development and Reform Commission, 2015). The past three years have witnessed the launching, expansion, faster-than-expected progress and fruitful outcomes of the Belt and Road Initiative (Ministry of Foreign Affairs of the People's Republic of China, 2017). From May 14 to 15, 2017, China hosted the "Belt and Road Forum for International Cooperation" (BRF) in Beijing and reached a series of cooperation consensus (BRF, 2017).

The implementation of the Belt and Road refers to politics, economy, technology, education, tourism, agriculture, industry and infrastructure. Although agriculture is one element of trade, it is also the basis for human survival and development. Furthermore, in the traditional farming civilization period, agricultural products trade and exchange is the main content of the land and maritime Silk Road. In the new period, agricultural cooperation plays an important role in implementing the Belt and Road, maintaining food security in the region and even the world and promoting the stable development of local economies (Li et al., 2016a). Moreover, countries along the Belt and Road have a long agricultural civilization, rich in agricultural resources and with a vast market. Agriculture occupies up a high proportion of the economic system in countries along the Belt and Road. As for the proportion of the agricultural added value to GDP, Afghanistan, Albania, Cambodia, Laos, Nepal and Pakistan have >20% (The World Bank, 2016b). The agricultural land in the spanning countries is relatively concentrated. Agricultural land, among the total land, is generally high, and nearly 20 countries have for >50% of land in agriculture (The World Bank, 2016a). Referring to the agricultural products trade, there is close bilateral trade between the spanning countries and China. In 2016, the agricultural products that China exported to the countries along the Belt and Road was approximately 8.60 billion dollars, while the imported amount was approximately 8.69 billion dollars from January to May, accounting for 31% and 20% of total export and import, respectively (Ministry of Commerce of the People's Republic of China Department of Foreign