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Environmental and Socioeconomic Determinants of Virtual Water Trade of Grain Products: An Empirical Analysis of South Korea Using Decomposition and Decoupling Model

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Abstract: The world's sustainable growth is being severely hampered by the inefficient use of water resources. Despite the widely acknowledged importance of trade in global and regional water and food security, societal reliance on local production, as well as international trade, remains inadequately assessed. Therefore, using South Korea as a case study, this study fills in this research gap by applying the virtual water concept, the logarithmic mean divisia index (LMDI) method, and the Tapio decoupling model. The virtual water concept was used to estimate South Korea's net virtual water trade for major grain crops from 1992 to 2017. Then, the LMDI method was utilized to assess the driving factors causing changes in net virtual water trade. Lastly, the Tapio decoupling model was used to investigate the decoupling relationships between economic growth and the driving factors of net virtual water trade. The results showed that South Korea remains a net importer of virtual water flows with respect to grain crops, with an average import of 16,559.24 million m^3 over the study period. In addition, the change in net virtual water trade could be attributed to the water intensity effect, product structure effect, economic effect, and population effect. However, water intensity and economic effects were the major decisive factors for decreases and increases in net virtual water trade, respectively, while the population and product structure effects had minor positive influences on the net virtual water trade. Furthermore, water intensity and economic growth showed a strong decoupling in most periods, while the decoupling state between product structure and economic growth was observed as expansive negative decoupling. Likewise, population size and economic growth showed a weak decoupling in most periods. The results reveal South Korea's status as it concerns the virtual water trade of grain crops, thus providing valuable insights into the sustainability of trade activities for the management of local water resources.

Keywords: virtual water trade; LMDI; Tapio decoupling model; driving factors; food security; South Korea

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1. Introduction

Water is a critical resource for human society's sustainable development. It is also essential for long-term environmental protection and economic growth [1]. In recent years, freshwater scarcity has put humanity's sustainability at risk [2–4]. For example, about two-thirds of the world's population (four billion people) experience acute water shortages for at least one month of the year [5], making the water crisis a major global concern in terms of its potential effect [6]. With increasing climatic influences, the population boom, expanded irrigated agriculture, changing consumption patterns and rapid economic development around the world, the demand for water is increasing [7–9]. However, due to disparities in global resource distribution patterns, the limited water supplies are unable to match rising water demand [10]. As a result, one of the main obstacles to many countries' sustainable development is the imbalance between the demand for and supply of water resources [1,11].

Water is a fundamental raw material for production; therefore, a country's potential agricultural production loss will be caused by water scarcity [12,13]. South Korea has a limited supply of water despite its high rainfall, placing the country in the water-stressed category amongst the Organization for Economic Co-operation and Development (OECD) countries. By 2015, South Korea had consumed up to 33% of its total available water, threatening the country's water balance. Additionally, the sustainable use of water is severely threatened by water stress and industrial water pollution [14]. South Korea's economic growth rate has been exceptionally high over the last few decades [15]. Regrettably, this economic development has come at the cost of the environment, as seen by water scarcity and declining water quality [16]. Freshwater resources are now much harder to access, which could cause further reduction and deterioration of the currently existing water supplies [14]. Therefore, it is of the utmost importance to manage water resources well in order to minimize water use per unit of economic growth, thereby reducing domestic water stress.

Through the virtual water trade (VWT) and water footprint (WF) concepts introduced by Allan and Hoekstra in the early 1990s and 2000s, respectively, the water demand for food production and water shortage can be realistically assessed for effective water resource management [17]. While the WF quantifies the amount of water utilized in the production of goods, the VWT deals with the trade of water contained in food products [18]. In order to save domestic water resources, several water-stressed regions such as South Korea tend to import agricultural products from regions with higher water productivity, thus reducing global water use and enabling global water savings [19]. Over the years, studies on WF and VWT have increased tremendously. Most of these studies are focused on water consumption calculation and water use efficiency and sustainability analysis [20,21], using research methods such as the water footprint method and input–output method. While these methods can capture actual water consumption and use efficiency, virtual water studies still have to be improved, particularly in the prediction and analysis of virtual water driving forces [17].

The logarithmic mean divisia index (LMDI) method, known for its characteristic uniqueness and consistency, is a decomposition method that has been widely applied in the areas of energy and environmental research [22–24]. The LMDI approach's appeal originates from its several desirable features, including its theoretical underpinning, versatility, ease of use, and result interpretation [25]. In recent times, it has gradually gained recognition in the water resources field for the analysis of the drivers of water demand and supply [1,26]. For instance, Gao et al. [27] investigated the drivers of dynamic evolution in provincial production water usage. They found out that the changes in consumption level, population scale, and regional economic patterns were important factors promoting production water usage [27]. Song et al. [28] focused on the drivers of domestic grain virtual water flow, with China as a case study. They discovered that the outward push force and the inward pull force of the exporter and importer, respectively, were major drivers of inter-regional virtual water flows [28]. Qian et al. [26] reported trade structure as the main positive driver of virtual water trade imbalances. Kong et al. [1] analyzed the decoupling relationship of water footprint and economic growth, attributing the change of water footprint to efficiency, economic, and population effects (Table 1).

Table 1. Previous and current logarithmic mean divisia index (LMDI) studies in water resources.

Study	Study Period	Type of Study	Variables Utilized
[1]	2004–2017	Regional	• Water footprint • GDP • Population
[26]	2000–2016	Cross-Country	• Virtual water trade • GDP • Agricultural water withdrawal • Total renewable water resources • Population • Product structure
[28]	1997–2015	National	• Virtual water flows • Product structure • Population
[27]	2002–2012	Regional	• Water use • Per capita GDP • Population • Technology use
Current study	1992–2017	National	• Net virtual water trade • GDP • Population • Product structure

Note: Selected previous studies are included in the comparison.

Economic growth and water resource consumption are strongly associated; hence, it is important to investigate the linkages, especially as South Korea's economic level is on the rise [29], and water stress is also on the increase. Although the LMDI approach can identify the factors influencing changes in water resources, it cannot quantify the degree of decoupling between economic growth and water use [1]. Therefore, in recent years, decoupling analysis has become increasingly established for objectively quantifying the relationship between environmental stress and economic growth [30]. Tapio [31] firstly introduced a decoupling model based on elasticities, which produces more accurate findings than other decoupling methods [32]. This Tapio decoupling model has therefore been applied in the study of the decoupling relationship between economic growth and water consumption [33,34].

While the LMDI method and Tapio decoupling model have been widely used in the fields of energy and environment, their use in the field of water resources has been largely limited globally, and in South Korea in particular. To achieve coordinated development of the water sector and economic growth, research is required to determine the factors influencing water consumption, and to investigate the decoupling relationship between economic growth and water consumption [1]. Therefore, this study aims to conduct a detailed analysis of the embedded water flows and underlying key drivers in relation to South Korea's trade of agricultural grain products, as well as the decoupling relationship between economic growth and the drivers of the virtual water flows. Specifically, the main objectives include the following: (1) to estimate South Korea's net virtual water trade for major grain (barley, buckwheat, maize, millet, wheat, soybeans and sorghum) crops between 1992–2017; (2) to identify the driving factors of grain virtual water trade using the LMDI method; (3) to assess the decoupling relationship between the driving factors of virtual water trade and economic growth. The research focused on South Korea as a case study, and will provide insight on the sustainability of historical trade practices and produce useful policy suggestions for the long-term growth of the economy and management of water resources. South Korea was selected as the study area due to its relatively limited research in terms of the virtual water trade [35], as well as its high-level involvement in international food trade [36].

The rest of this paper is organized as below. Section 2 introduces the study area, the methodology, and the data source. Section 3 provides the results of the detailed analysis and discussion, and Section 4 shows the conclusions.

2. Methods and Data

2.1. Study Area

Located between latitudes 33° and 39° N and longitudes 124° and 130° E, South Korea has an elevation range of 0–1950 m above sea level. The nation, which is located in the southern side of the Korean peninsula, has a total area of 100,032 km^2 that is mostly mountainous (about 70%), and a population of approximately 51.71 million [37]. For administrative purposes, it is divided into nine (9) provinces: Gyeonggi, Gangwon, North Chungcheon, South Chungcheon, North Gyeongsang, South Gyeongsang, North Jeolla, South Jeolla, and Jeju. The Asian monsoon influences the Korean climate, with distinctive monsoon winds and a combination of oceanic and continental elements. This brings about four different seasons, including summer (characterized by heavy rainfalls with humid and hot temperatures), winter (extremely cold temperatures), spring and autumn (occasional rainfall and fluctuating temperatures). The country also comprises four main rivers that empty into the West and South Sea (Figure 1) [38]. They include the Han River (the largest river, with a length of 481.7 km), the Nakdong River (the longest river, with a length of 506.17 km), the Geum River (with a length of 394.79 km), and the Yeongsan River (with a length of 115.5 km) [38].

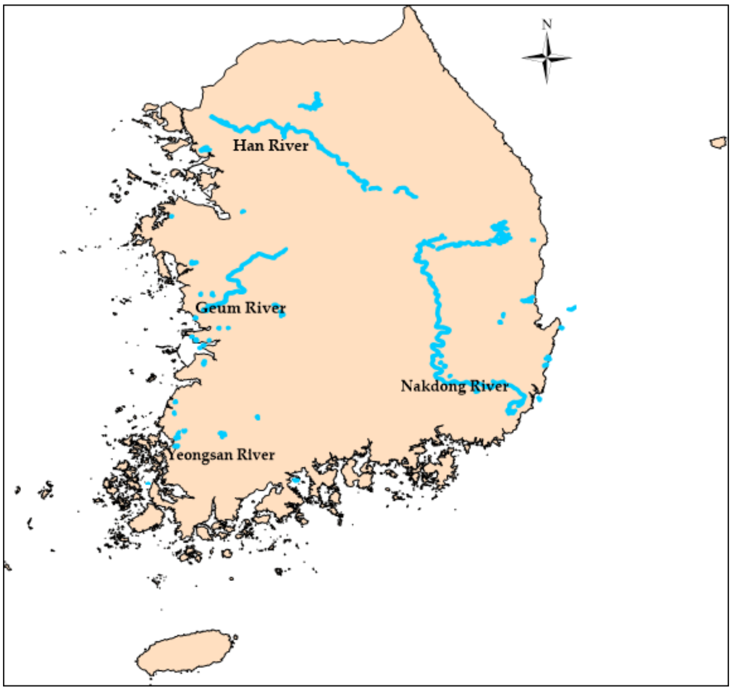

Figure 1. Map showing South Korea's water resources.

South Korea's total water resources are estimated at 129.7 billion m^3. However, the renewable water resources are slightly above half (75.3 billion m^3), which are mostly discharged during the period of heavy rainfall (summer). For human activities, about 62% of the available water is used for agricultural purposes, with domestic and industrial purposes expending about 30% and 8%, respectively [39]. In terms of the economy, South Korea's nominal GDP has increased over the years, with an annual growth rate estimated at 14.2% [15]. The growth in economy could be attributed to heavy industrialization and technological advancement. Despite this soaring economic growth, South Korea's per capita water consumption still ranks the highest amongst the OECD member countries [40]. Hence, in order to reduce possible pressure on domestic water resources, the trade (import) of goods in the form of virtual water serves as a viable solution, especially for grain crops that make up the bulk of the country's agro-trade [41]. Accordingly, it is vital to clearly define the major drivers influencing this VWT and examine the decoupling status between the drivers and economic growth, with the goal of providing some realistic recommendations relevant to governments and policymakers.

2.2. South Korea's Net Virtual Water Trade for Grain Crops

The basis for assessing the amount of net virtual water trade in grain products between South Korea and its trading partners is called crop-specific virtual water content (VWC). The virtual water concept states that the exchange of products between geographical locations brings about the exchange of water in its virtual form. Therefore, the VWT is calculated using the water footprints of exporters and importers, which show the overall volume of water used for crop production, as well as the trade data [42]. Accordingly, South Korea's gross volume of grain virtual water export (GVWE) is estimated as:

$$\mathrm{GVWE_{tij}} = \Sigma\ (\mathrm{Crop\ Product\ Exports_{pt}} \times \mathrm{VWC_{pi}}) \tag{1}$$

The gross volume of grain virtual water import (GVWI) to South Korea is calculated as:

$$\mathrm{GVWI_{tij}} = \Sigma\ (\mathrm{Crop\ Product\ Imports_{pt}} \times \mathrm{VWC_{pi}}) \tag{2}$$

where j signifies the importing country, i is the exporting country, p is the grain product, t is the time, and VWC is virtual water content.

The net virtual water trade (NVWT) is thus given as:

$$\mathrm{NVWT_{tij}} = \mathrm{GVWI_{tij}} - \mathrm{GVWE_{tij}} \tag{3}$$

2.3. Grain Virtual Water Trade Decomposition

To explore the driving factors and the impact of grain virtual water trade on national water resources, this research presented a decomposition technique based on the LMDI methodology that connects virtual water trade to domestic water scarcity. The driving factors were decomposed into water intensity, product structure, economic level, and population size as shown in Equations (4) and (5):

$$\mathrm{VWT} = \sum_i VWT_i = \sum_i \frac{VWT_i}{GDP}.\frac{V_i}{V}.\frac{GDP}{P}.P = \sum_i WI.PS.ES.P \tag{4}$$

$$\Delta\mathrm{VWT}_{total} = \Delta\mathrm{WI} + \Delta\mathrm{PS} + \Delta\mathrm{ES} + \Delta\mathrm{P} \tag{5}$$

where VWT_i represents the total virtual water trade of product i; GDP represents the actual gross domestic product; V_i refers to the monetary trade volume of product i; V refers to the total monetary trade volume of grain products; P represents the population; ΔWI represents water intensity effect; ΔPS denotes the product structure effect; ΔES represents economic effect; ΔP refers to the population effect; and ΔVWT_{total} represents the total effect of virtual water trade.

$$\Delta\mathrm{U} = \sum_i \frac{VWT_{i,t} - VWT_{i,0}}{\ln VWT_{i,t} - \ln VWT_{i,0}} \ln \frac{\mathrm{U}_{i,t}}{\mathrm{U}_{i,0}} \tag{6}$$

where U represents the four effects mentioned above, and subscripts t and 0 denote the final and base year, respectively.

2.4. Tapio Decoupling Elasticity Model

The ratio of the variation rate of economic growth to the variation rate of environmental pressure over a given time period is known as the Tapio decoupling elasticity coefficient. Tapio [31] developed a decoupling model by combining the elasticity coefficient approach in order to quantify the degree of decoupling. According to three decoupling categories of negative coupling, coupling and decoupling, the Tapio model is divided into eight decoupling states (Table 2). These eight decoupling states are based on three critical values of 0, 0.8, and 1.2. In general, strong decoupling is typically the ideal decoupling state since environmental pressure decreases with economic growth, whereas strong negative decoupling is the worst scenario because environmental pressure increases with an economic decline [1]. With respect to this study, however, the increasing pace of VWT should be less than that of economic growth (weak decoupling). The worst-case scenario actually occurring entails an economic crisis. The formula is stated as follows:

$$X = \frac{\Delta EP_i^t / EP_i^0}{\Delta G_i^t / G_i^0} = \frac{\left(EP_i^t - EP_i^0\right) / EP_i^0}{\left(G_i^t - G_i^0\right) / G_i^0} \quad (7)$$

where X is the decoupling elasticity index; EP denotes the environmental pressure (VWT decomposition effects); G refers to the economic indicator (actual GDP); t and 0 represent the current year and base year, respectively; and ΔEP and ΔG indicate the increment in environmental pressure and GDP in a given period.

Table 2. Eight possible decoupling outcomes and their interpretations.

Decoupling Category	Decoupling State	ΔX/X	ΔGDP/GDP	Elasticity Coefficient	Interpretation
Negative coupling	Expansive negative decoupling (END)	>0	>0	(1.2, +∞)	The increasing pace of driving factor (X) is largely greater than that of economic growth (GDP).
	Strong negative decoupling (SND)	>0	<0	(−∞, 0)	Driving factor (X) increases while economic growth (GDP) decreases.
	Weak negative decoupling (WND)	<0	<0	(0, 0.8)	The decreasing pace of driving factor (X) is largely smaller than that of economic growth (GDP).
Coupling	Expansive coupling (EC)	>0	>0	(0.8, 1.2)	The increasing pace of driving factor (X) is relatively equal to that of economic growth (GDP).
	Recessive coupling (RC)	<0	<0	(0.8, 1.2)	The decreasing pace of driving factor (X) is relatively equal to that of economic growth (GDP).
Decoupling	Weak decoupling (WD)	>0	>0	(0, 0.8)	The increasing pace of driving factor (X) is less than that of economic growth (GDP).
	Strong decoupling (SD)	<0	>0	(−∞, 0)	Driving factor (X) decreases while economic growth (GDP) increases.
	Recessive decoupling (RD)	<0	<0	(1.2, +∞)	The decreasing pace of driving factor (X) is largely greater than that of economic growth (GDP).

Modified from [31].

Therefore, the decoupling elasticity index between each environmental pressure and economic growth would be calculated as:

$$X_{wi} = \frac{\left(WI_i^t - WI_i^0\right) / WI_i^0}{\left(G_i^t - G_i^0\right) / G_i^0} \quad (8)$$

$$X_{ps} = \frac{\left(PS_i^t - PS_i^0\right) / PS_i^0}{\left(G_i^t - G_i^0\right) / G_i^0} \quad (9)$$

$$X_p = \frac{\left(P_i^t - P_i^0\right) / P_i^0}{\left(G_i^t - G_i^0\right) / G_i^0} \quad (10)$$

where X_{wi}, X_{ps}, and X_p represent the water intensity, product structure, and population effects, respectively.

2.5. Data Sources

The agricultural trade data for seven grain products, including barley, buckwheat, maize, millet, wheat, soybeans and sorghum, was obtained from the Food and Agriculture Organization (FAO) database [43] for the period 1992–2017 (Table 3). A country's water footprint is influenced by its climate, irrigation, and productivity. As a result, determining the water footprint of all the countries included in this research would be time-consuming and beyond the scope of this study. Therefore, data on the water footprint of studied grain crops were collected from reliable sources. For the crop-specific water footprint of local production, data was obtained from [44], while water footprint data for South Korea's trade partners were obtained from [45]. The trade and water footprint data acquired were used to compute the net virtual water trade of grain products between South Korea and trade partner countries. Furthermore, the population and GDP data for South Korea employed in this study were acquired from the FAO and World Bank database [46].

Table 3. Overview of data sources.

Input	Sources
Net virtual water trade	Author estimation
Gross domestic product (GDP)	[46]
Population	[43]
Trade matrix	[43]
Water footprint	[44,45]

3. Results

3.1. Net Volume of Grain Virtual Water Trade

Numerous studies have emphasized the contribution of virtual water trade on water conservation and food security [47,48]. Water savings are produced by the variations in water production among trade partner nations. As a result, nations with a water shortage can benefit from virtual water imports from countries with water surpluses, rather than creating water-intensive goods domestically [42]. Between 1992 and 2017, the average amount of virtual water import (VWI) for grain products to South Korea was estimated at 16,559.24 million m^3, while grain product virtual water exports (VWE) from South Korea stood at an average of 1.79 million m^3 (Table 4). Despite the fact that both the VWI and the VWE exhibited increasing trends, there was a significant disparity in the volumes of virtual water imported and exported. While the minimum and maximum grain VWI stood at 11,314.77 and 22,393.93 million m^3, respectively, the minimum and maximum grain VWE was 0.13 and 6.10 million m^3, respectively.

Accordingly, the quantity of net virtual water trade shows that for the past 26 years, South Korea has been a net importer of virtual water in grain products (Figure 2). This is in line with the findings of [41] that Korea remains a major importer of grain products from the international market. This high importation is due to a decrease in the food self-sufficiency ratio, attributed to changes in production and consumption patterns. The grain crops involved in this study are primarily rain-fed in South Korea, hence could be affected by several factors. Even though the country produces these crops, available reports suggests that local demand cannot be met with domestic production due to such factors as rapid industrialization and urbanization that have led to decreased arable lands [41]. Additionally, water stress due to climatic influences that have become significant over the years [49], have resulted in a short supply of water for domestic agricultural production. Despite available farmland and advanced agricultural technology, a lack of water for local crop production could lead to a shortage of agricultural products. Since South Korea is a huge consumer of grain products, the increased level of grain virtual water imports could enable a reduction in domestic water stress, thus improving the management of water resources.

Table 4. South Korea's net virtual water trade for grain crops (million m^3).

Year	Virtual Water Import	Virtual Water Export	Net Virtual Water Trade
1992	13,925.24	0.33	13,924.91
1993	15,413.20	0.13	15,413.07
1994	16,507.76	0.32	16,507.44
1995	12,571.87	0.47	12,571.40
1996	12,239.55	3.52	12,236.04
1997	14,625.68	2.20	14,623.48
1998	15,756.42	0.62	15,755.80
1999	11,314.77	2.28	11,312.49
2000	15,684.22	4.20	15,680.02
2001	16,831.42	1.47	16,829.95
2002	18,473.55	1.15	18,472.40
2003	17,602.09	2.19	17,599.91
2004	16,413.20	2.54	16,410.66
2005	16,145.58	1.88	16,143.70
2006	15,101.36	0.89	15,100.47
2007	14,836.71	0.55	14,836.16
2008	13,864.38	0.91	13,863.47
2009	14,633.26	0.69	14,632.57
2010	15,916.62	1.43	15,915.20
2011	16,593.53	1.15	16,592.39
2012	22,016.46	0.97	22,015.50
2013	22,393.93	6.10	22,387.83
2014	19,279.16	1.51	19,277.65
2015	20,971.18	1.21	20,969.97
2016	21,420.94	3.48	21,417.45
2017	20,008.23	4.44	20,003.79
Average	**16,559.24**	**1.79**	**16,557.45**

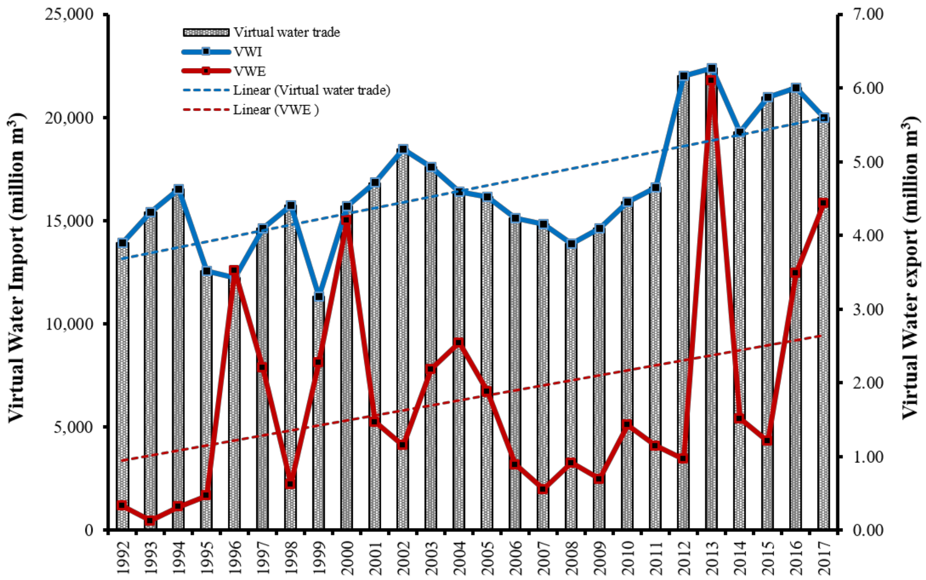

Figure 2. Net volume of the virtual water trade of grains in South Korea.

Figure 3 shows the product structure of grain virtual water flows into South Korea. Over the study period, the largest share of the virtual water flows was majorly associated with the trade in maize, wheat, and soybeans [41]. Barley, millet, sorghum and buckwheat recorded very low virtual water flows. In 1992, 44% of grain virtual water inflow was from wheat trade, followed by maize (38%) and soybeans (16%). Between 1993 and 1997, 51% of the inflow was from wheat trade, followed by maize (29%) and soybeans (19%). For the periods 1998–2002, 47% of the inflow came from maize trade, followed by wheat (38%) and soybeans (14%). Similarly, maize trade had the largest virtual water inflow (46%) in the periods 2003–2007, followed by wheat (37%) and soybeans (16%). In the period 2008–2012, wheat recorded the highest amount of virtual water inflow with 49%, followed by maize (39%) and soybeans (11%). For the periods 2013–2017, maize grain (47%) recorded the highest volume of inflow, followed by wheat (39%) and soybeans (13%).

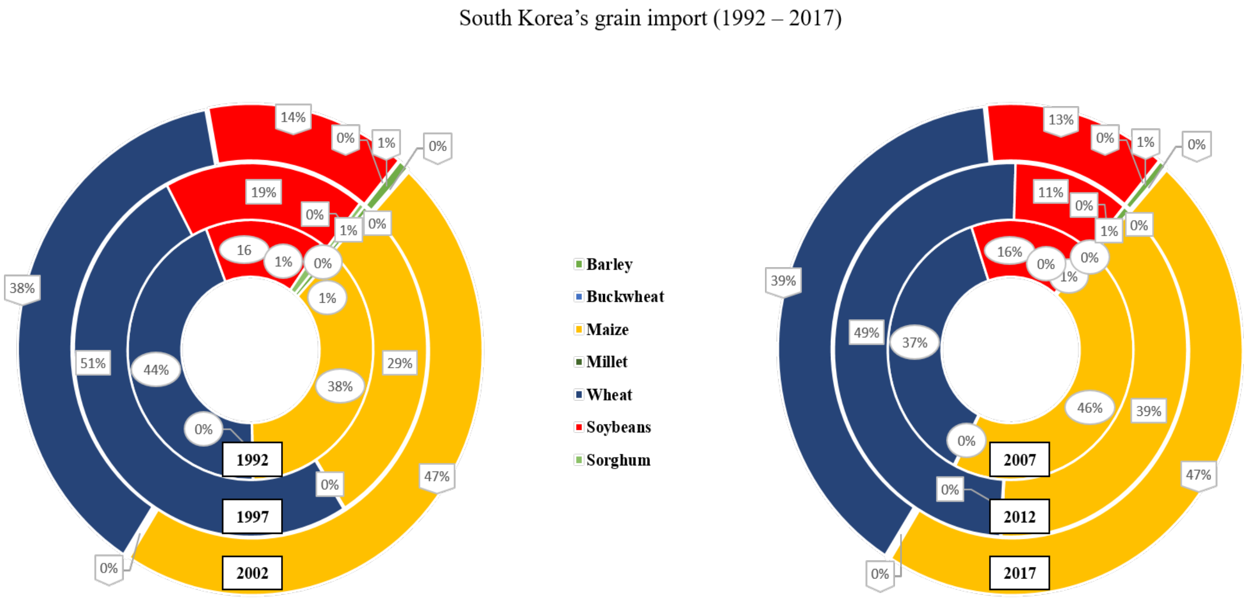

Figure 3. Product structure of grain virtual water flows into South Korea (1992–2017).

3.2. Driving Factors of Net Virtual Water Trade

A decomposition analysis of the main driving factors of net virtual water trade was employed to examine the environmental and economic implications of grain virtual water trade between South Korea and its trade partners. Using the LMDI model (Equations (4)–(6)), the change in VWT can be decomposed into the water intensity effect, product structure effect, economic effect, and population effect. The results of the calculation are shown in Table 5 and Figure 4. According to Table 5, the total effect (ΔVWT_{total}) indicating the yearly virtual water import of South Korea increased by 6545.063 million m^3 from 1992 to 2017. Additionally, the net virtual water import increased in most years, with the growth rate showing a fairly increasing trend throughout the study period. Furthermore, the annual virtual water import only decreased in 1994–1995, 1995–1996, 1998–1999, 2002–2003, 2003–2004, 2005–2006, 2006–2007, 2007–2008, 2013–2014, and 2016–2017, with the largest decline recorded in 1994–1995, which was 6228.293 million m^3.

In terms of the decomposition effects, the water intensity effect (i.e., the grain virtual water trade per unit of actual GDP) was negative for most of the years. With a value of 18853.423 million m^3 from 1992 to 2017, the water intensity effect could be said to be the decisive factor of a reduction in grain virtual water trade from South Korea. Specifically, the negative values of water intensity implied that the virtual water import per unit dollar of GDP in South Korea evidently decreased. The largest reduction was observed in 1998–1999, with a value of 7879.245 million m^3, while the least reduction occurred in 2015–2016, with a value of 42.631 million m^3. In addition, the product structure effect (i.e., the share of a particular product in the total trade volume), the economic effect (i.e., the actual GDP per capita), and the population effect were mostly positive throughout the study periods (1992–2017), even though the product structure effect was largely fluctuating. The economic effect was also observed to be larger than the population and product structure effects. Over the study period, the economic structure effect increased by 22,382.239 million m^3, while the population and product structure effects increased by 2550.063 and 466.184 million m^3, respectively. This implies that the increase in economic development level, expansion of local population, and an increase in variety of import products will increase South Korea's virtual water trade. However, the net virtual water trade is mainly dependent on economic development rather than population growth and product variety, meaning the economic effect is the main driver of increased net virtual water trade, with population and product structure effects playing minor roles in promoting increased grain net virtual water trade in South Korea.

The virtual water trade was also decomposed to the specific grains using the LMDI method, and the results are presented in the Appendix A (see Tables A1–A7). Water intensity and economic structure effects mainly influenced the changes in the virtual water trade of barley, buckwheat, maize, millet, wheat, soybeans, and sorghum. Just like the decomposition results above (Table 5), the water intensity effect and economic effect were the main drivers for the reduction and increase in the net virtual water trade of all the studied grain products, respectively. In terms of the total effect, the virtual water trade showed an overall increasing trend from 1992 to 2017 for all grains except barley and sorghum. The virtual water trade for buckwheat, maize, millet, wheat, and soybeans, increased by 5.488, 5035.652, 45.325, 1486.468, and 347.381 million m^3, respectively; while barley and sorghum decreased by 43.260 and 331.991 million m^3, respectively. The larger increases in maize, wheat, and soybeans show that they have a greater influence on South Korea's overall grain virtual water trade.

Table 5. The logarithmic mean divisia index (LMDI) analysis of grain virtual water trade (VWT) change in South Korea (million m^3).

Year	VWT Change				
	Water Intensity Effect	**Product Structure Effect**	**Economic Effect**	**Population Effect**	**Total Effect**
1992–1993	37.658	757.951	1302.214	148.289	2246.112
1993–1994	−1552.541	189.664	2486.576	160.331	1284.031
1994–1995	−6786.401	−2292.256	2707.359	143.005	−6228.293
1995–1996	−1253.201	320.200	799.839	117.995	−15.167
1996–1997	3293.102	60.481	−1029.592	123.931	2447.921
1997–1998	7138.040	1481.252	−6115.109	109.393	2613.576
1998–1999	−7879.245	−240.695	3342.263	93.672	−4684.004
1999–2000	2409.411	−135.712	1846.581	111.539	4231.819
2000–2001	1974.505	260.213	−949.186	124.608	1410.140
2001–2002	−750.469	−71.808	2290.999	101.922	1570.645
2002–2003	−2920.913	−20.894	1954.964	93.454	−893.389
2003–2004	−3243.665	−313.216	1987.176	67.240	−1502.465
2004–2005	−2937.230	337.569	2635.837	34.435	70.611
2005–2006	−2903.335	−87.458	1778.125	81.982	−1130.686
2006–2007	−1870.335	−259.344	1530.462	75.561	−523.656
2007–2008	646.421	94.707	−1727.925	108.815	−877.983
2008–2009	2243.042	534.493	−1546.925	72.983	1303.593
2009–2010	−1652.154	−154.128	2858.739	76.044	1128.501
2010–2011	−803.625	604.868	1355.859	124.955	1282.056
2011–2012	5041.655	98.584	280.744	100.710	5521.693
2012–2013	−1168.903	−281.479	1440.665	100.573	90.856
2013–2014	−4762.808	−566.980	1522.153	130.472	−3677.162
2014–2015	1945.075	158.742	−358.755	106.003	1851.065
2015–2016	−42.631	21.831	406.119	83.995	469.314
2016–2017	−3054.876	−30.403	1583.058	58.156	−1444.065
Sum	−18,853.423	466.184	22,382.239	2550.063	6545.063

Note: Since the VWE was negligible (as reported in Section 3.1), the decomposition of net virtual water trade mainly explained the VWI.

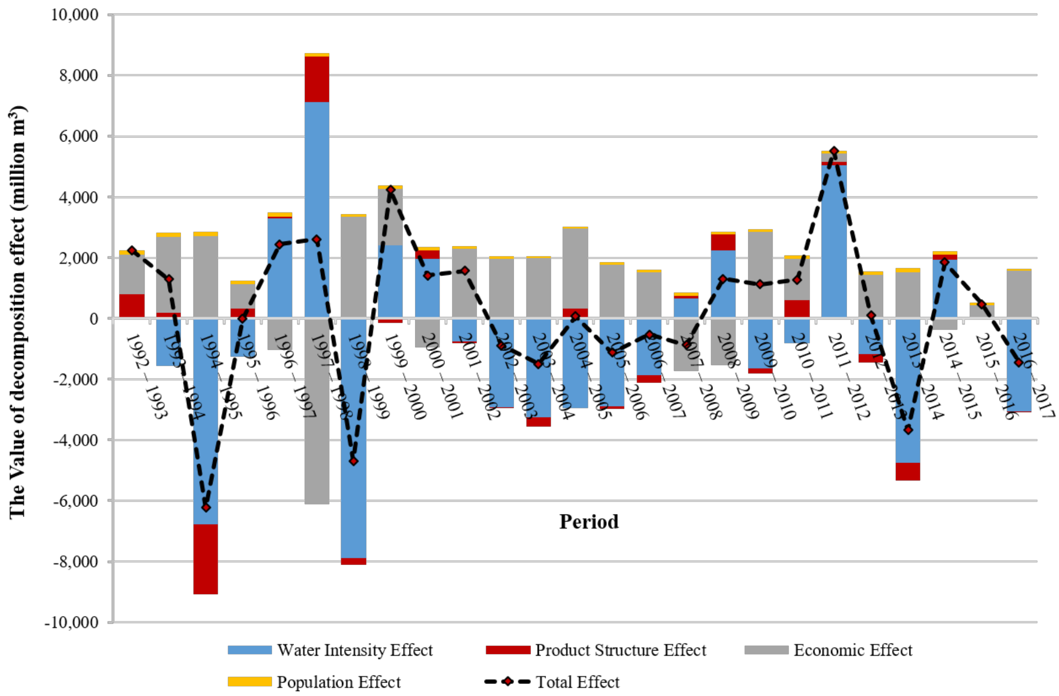

Figure 4. The change trend of grain virtual water trade (VWT) logarithmic mean divisia index (LMDI) decomposition effect.

3.3. Analysis of Decoupling Characteristics of South Korea's Net Virtual Water Trade

Figure 5 shows the relationship between actual GDP (economic development) and net virtual water trade during the study period. Between 1992 and 2017, actual GDP and net virtual water trade recorded increasing trends, with the net virtual water trade showing more significant fluctuations. It is evident that the growth rate of net virtual water trade is highly correlated with the level of economic development. However, the growth rate of net virtual water trade was typically lower than the economic growth rate, hence buttressing on the result of the LMDI analysis concerning the water intensity effect. Furthermore, a situation such as this, where the economy and net virtual water trade both increase simultaneously, but the economic growth rate is greater than the net virtual water trade, indicates a weak decoupling state.

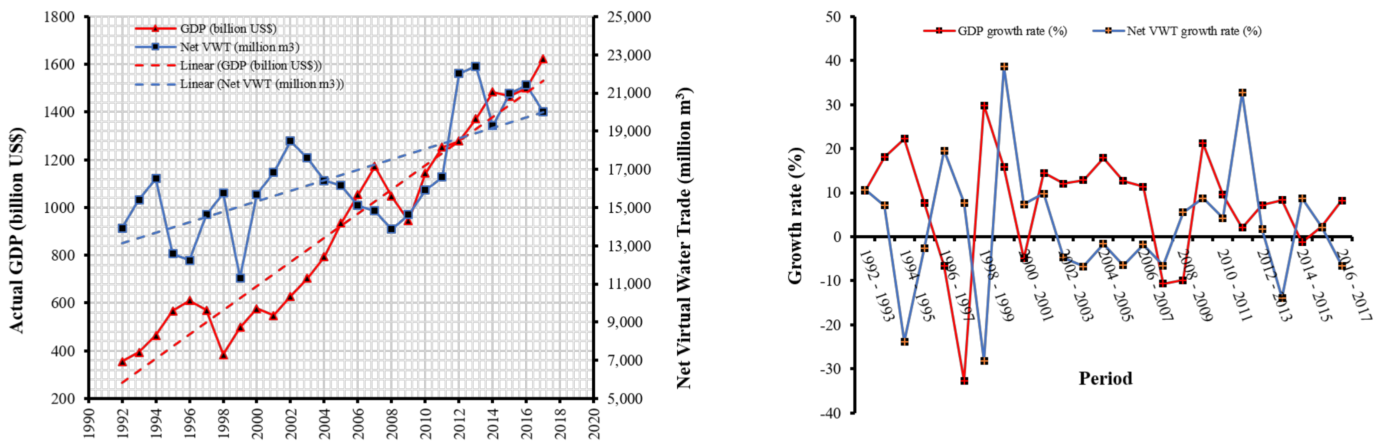

Figure 5. The change trend of grain net virtual water trade and economic growth (GDP) in South Korea (1992–2017) [first graph shows the trend of actual GDP against net virtual water trade; second graph shows the growth rates of actual GDP and net virtual water trade].

The results of the decoupling state between drivers of grain net virtual water trade and economic growth are represented in Table 6. The elasticity of decoupling was calculated for each pair of years from 1992 to 2017 in South Korea. The main decoupling states observed were strong decoupling, expansive negative decoupling, weak decoupling, and expansive coupling. There was no decoupling between the economic effect and GDP growth because they are both economic measures. In most years, the decoupling state between water intensity and GDP was depicted as strong decoupling. This implies that for the majority of the periods, the water intensity in South Korea decreased with economic growth. Moreover, the product structure and GDP showed expansive negative decoupling in most years, depicting that the increasing pace of product structure was largely greater than that of economic growth. This is understandable, since there has been an increase in grain dependence in South Korea, depicted by the increase in the variety of grain imports over the study period. Additionally, the population effect and GDP showed weak decoupling in most years, indicating that the growth rate of the population size was lower than that of the GDP.

Table 6. Decoupling status of the driving factors of virtual water trade (VWT) and economic growth (GDP).

Year	Decoupling Elasticity of Water Intensity and GDP	Decoupling Status	Decoupling Elasticity of Product Structure and GDP	Decoupling Status	Decoupling Elasticity of Population Size and GDP	Decoupling Status
1992–1993	−0.88891	Strong decoupling	2.51624	END	0.68413	Weak decoupling
1993–1994	−6.57933	Strong decoupling	−3.61510	Strong decoupling	0.39174	Weak decoupling
1994–1995	1.84306	END	10.57744	END	0.31876	Weak decoupling
1995–1996	22.97925	END	27.63861	END	0.87111	Expansive coupling
1996–1997	−5.88652	Strong decoupling	4.70734	END	−0.99574	Strong decoupling
1997–1998	−6.02349	Strong decoupling	1.59051	END	−0.15499	Strong decoupling
1998–1999	0.13148	Weak decoupling	7.40025	END	0.16763	Weak decoupling
1999–2000	4.70536	END	3.05760	END	0.37174	Weak decoupling
2000–2001	−30.20644	Strong decoupling	−5.91180	Strong decoupling	−1.08908	Strong decoupling
2001–2002	−5.04942	Strong decoupling	−2.97002	Strong decoupling	0.27919	Weak decoupling
2002–2003	−7.93676	Strong decoupling	−1.78655	Strong decoupling	0.30234	Weak decoupling
2003–2004	180.50964	END	31.74504	END	0.21594	Weak decoupling
2004–2005	−11.22938	Strong decoupling	−0.21111	Strong decoupling	0.08314	Weak decoupling
2005–2006	−14.64117	Strong decoupling	−0.56057	Strong decoupling	0.29126	Weak decoupling
2006–2007	19.64819	END	19.85681	END	0.31276	Weak decoupling
2007–2008	2.73515	END	13.08692	END	−0.49941	Strong decoupling
2008–2009	−1.21090	Strong decoupling	−11.81615	Strong decoupling	−0.36588	Strong decoupling
2009–2010	−2.81176	Strong decoupling	1.49066	END	0.16491	Weak decoupling
2010–2011	7.92047	END	7.23773	END	0.56635	Weak decoupling
2011–2012	53.85485	END	1.58460	END	1.83459	END
2012–2013	−4.48177	Strong decoupling	3.94634	END	0.44204	Weak decoupling
2013–2014	−6.37136	Strong decoupling	6.30188	END	0.53262	Weak decoupling
2014–2015	−13.04215	Strong decoupling	−19.22974	Strong decoupling	−2.96206	Strong decoupling
2015–2016	−17.48505	Strong decoupling	16.15569	END	1.18816	Expansive coupling
2016–2017	−4.31514	Strong decoupling	−1.65950	Strong decoupling	0.23867	Weak decoupling

END—Expansive negative decoupling.

4. Discussion

This study analyzed the embedded water flows of South Korea's trade of agricultural grain products. Additionally, the underlying key drivers of changes in net virtual water trade, and the decoupling relationship between economic growth and the decomposed drivers of grain net virtual water flows, were identified using the LMDI and Tapio elasticity model, respectively.

The results show that the average virtual water import (VWI) for grain products into South Korea between 1992 and 2017 was reported at 16,559.24 million m^3, while the average virtual water export (VWE) for grain products out of South Korea was 1.79 million m^3 (Table 4), implying that the country is largely a net virtual water importer of grain products [41]. In addition, the trade in maize, wheat, and soybeans made up a greater proportion of the grain virtual water flows during the study period, implying that these grains are important in the realization of food self-sufficiency in South Korea.

Additionally, the changes in net virtual water trade can be linked to the water intensity effect, product structure effect, economic effect, and population effect. The economic effect, in particular, was the main driving force for the increase in net virtual water trade, indicating that increased economic growth facilitates the trade of grain products [50]. For countries with a high economic level such as South Korea, the availability of local water resources has little influence on purchasing power, but economic strength limits the positive effect of water scarcity on virtual water trade [51]. On the other hand, the water intensity effect was the decisive factor for the decrease in net virtual water trade. Available studies in South Korea have shown that increased awareness about water conservation, and the use of water-saving technology (such as improved irrigation techniques), would increase domestic yield of major staples [52,53]. The product structure effect and population effect exerted minor positive influences on the net virtual water trade of the grain products, even though the population effect was more significant. This suggests that between 1992 and 2017, the increase in South Korea's net virtual water trade could be attributed more to the increased purchasing power than an increase in the population size or variety of import products (dietary change). Studies by Wang et al. [54] and Kong et al. [1] also reported similar findings.

Regarding the outcomes of the Tapio decoupling analysis, water intensity and GDP depicted strong decoupling for most of the periods, suggesting that the virtual water trade decreases slower with the growth in GDP. The logical explanation is that higher GDP implies higher domestic consumption and consequently reduced exports of local products [50]. In addition, the decoupling state between product structure and economic growth was mainly expansive negative decoupling. This implies that the increasing pace of product structure was largely greater than that of economic growth. The decoupling of product structure and economic growth significantly explained the level of dependence on grain imports in South Korea, and the decoupling state was proof that the country still significantly depends on the importation of grain products to meet local needs. Furthermore, the weak decoupling status between population size and GDP for most of the periods, could suggest the positive influence of population size on South Korea's economic growth.

Based on the findings of this study, the following policy measures could therefore enhance the synergy of South Korea's water resources and economic growth, with respect to virtual water trade. Firstly, the government/industry should significantly promote the research and development of water-saving technologies while also growing the economy. This will, in addition to aiding the making of informed water management decisions [55], improve domestic water utilization in order to raise local grain output. Secondly, there is a need to improve farmers' water conservation awareness [53] while also increasing imports of more water-intensive grains to relieve pressure on local water resources. Thirdly, to mitigate future water concerns, the Korean government and its trade partners should strike a balance between water governance for sustainable local production and water governance along international trade lines in order to improve resilience and achieve sustainable economic development.

5. Conclusions

This study calculated the net virtual water trade of significant grains in South Korea from 1992 to 2017 using the virtual water concept. The driving factors influencing the change in net virtual water trade were then decomposed using the LMDI approach. From the contexts of total effect, water intensity effect, product structure effect, economic effect, and population effect, the dynamic change of net virtual water trade was examined. Finally, the Tapio decoupling model examined the state of decoupling between the driving forces of net virtual water trade and economic growth. The following conclusions were reached:

1. South Korea was a significant importer of grains (especially maize, wheat, and soybeans). Despite rising trends in both the VWI and the VWE, there was a considerable

gap in the volumes of virtual water imported and exported between 1992 and 2017. Population increase and lifestyle changes over the past 50 years have had an impact on the demand and supply of food, as well as the usage of land and water. Understanding these changes is crucial for the management of water resources.

2. The most important drivers of net virtual water flows were the economic and water intensity effects. The difference is that whereas the water intensity had a substantial negative impact on net virtual water trade, the economic effect had a positive one. Product structure and population effects, on the other hand, had a smaller impact on the increase in net virtual water trade.
3. The decoupling status between water intensity and economic growth was strong decoupling, while product structure and economic growth showed expansive negative decoupling. In addition, the decoupling status between population size and economic growth was mainly weak decoupling for most of the study periods.

It is safe to say that environmental changes and long-term alterations in socioeconomic factors have influenced the characteristics of water availability and supply in South Korea. However, the country has developed water management strategies in response to changing environmental conditions over time, as evidenced by the improved utilization of local water resources in grain production, regardless of the fact that production is not yet at an economic level to significantly affect grain imports.

Despite the fact that there are not many studies on the determinants of virtual water flow, the current study has significantly added to the body of knowledge, especially as it concerns South Korea. However, more research is needed, particularly given the uncertainty surrounding the availability and accuracy of data, to predict and analyze the driving factors for virtual water. Furthermore, because virtual water research is interdisciplinary, more studies should be undertaken in collaboration with appropriate knowledge from other environmental and socioeconomic-related disciplines.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. The logarithmic mean divisia index (LMDI) analysis of barley virtual water trade (VWT) change in South Korea (million m^3).

Year	VWT Change				
	Water Intensity Effect	Product Structure Effect	Economic Effect	Population Effect	Total Effect
1992–1993	−48.644	−39.178	8.109	0.923	−78.790
1993–1994	3.055	1.047	12.555	0.810	17.467
1994–1995	−3.495	38.405	18.417	0.973	54.300
1995–1996	18.485	12.551	7.617	1.124	39.777
1996–1997	−57.313	−57.985	−7.526	0.906	−121.918

Table A1. *Cont.*

Year	VWT Change				
	Water Intensity Effect	**Product Structure Effect**	**Economic Effect**	**Population Effect**	**Total Effect**
1997–1998	31.057	16.852	−28.173	0.504	20.240
1998–1999	13.269	17.453	22.432	0.629	53.783
1999–2000	5.820	36.913	16.491	0.996	60.220
2000–2001	52.508	19.398	−8.910	1.170	64.165
2001–2002	−64.218	−44.450	19.901	0.885	−87.882
2002–2003	−33.949	−16.395	13.249	0.633	−36.462
2003–2004	−25.305	−47.203	12.425	0.420	−59.662
2004–2005	−16.247	20.187	16.240	0.212	20.391
2005–2006	−69.981	−52.677	7.292	0.336	−115.030
2006–2007	19.328	35.215	5.025	0.248	59.815
2007–2008	4.716	−8.986	−7.393	0.466	−11.197
2008–2009	−26.121	−26.607	−4.703	0.222	−57.209
2009–2010	15.122	9.352	7.479	0.199	32.152
2010–2011	22.194	13.418	5.464	0.504	41.579
2011–2012	58.636	60.753	1.585	0.568	121.542
2012–2013	−52.069	−36.159	7.701	0.538	−79.990
2013–2014	21.269	16.146	8.203	0.703	46.322
2014–2015	0.877	13.718	−2.272	0.671	12.994
2015–2016	−61.702	−35.511	1.806	0.373	−95.034
2016–2017	31.486	16.927	6.513	0.239	55.165
Sum	−161.223	−36.815	139.525	15.253	−43.260

Table A2. The logarithmic mean divisia index (LMDI) analysis of buckwheat virtual water trade (VWT) change in South Korea (million m^3).

Year	VWT Change				
	Water Intensity Effect	**Product Structure Effect**	**Economic Effect**	**Population Effect**	**Total Effect**
1992–1993	1.309	1.452	0.310	0.035	3.106
1993–1994	−2.373	−2.389	0.528	0.034	−4.200
1994–1995	1.908	2.595	0.710	0.038	5.251
1995–1996	−3.491	−3.375	0.215	0.032	−6.619
1996–1997	0.271	0.154	−0.158	0.019	0.287
1997–1998	1.086	0.592	−0.889	0.016	0.805
1998–1999	0.316	0.852	0.711	0.020	1.899
1999–2000	2.131	1.805	0.640	0.039	4.615
2000–2001	1.373	0.551	−0.390	0.051	1.586
2001–2002	−0.253	−0.353	0.985	0.044	0.423
2002–2003	−3.735	−3.479	0.689	0.033	−6.492
2003–2004	1.031	0.906	0.678	0.023	2.638
2004–2005	−0.462	2.746	1.142	0.015	3.441
2005–2006	−1.277	4.759	0.818	0.038	4.338
2006–2007	−0.968	−2.699	0.702	0.035	−2.931
2007–2008	0.183	−2.820	−0.779	0.049	−3.367
2008–2009	−1.440	0.414	−0.561	0.026	−1.561
2009–2010	−1.339	0.360	0.734	0.020	−0.226
2010–2011	0.860	0.644	0.352	0.032	1.889
2011–2012	−0.999	−2.383	0.065	0.023	−3.294
2012–2013	0.237	0.811	0.276	0.019	1.343
2013–2014	0.600	1.889	0.365	0.031	2.885
2014–2015	−1.348	0.385	−0.085	0.025	−1.023
2015–2016	0.574	1.913	0.085	0.018	2.589
2016–2017	−0.137	−2.143	0.374	0.014	−1.893
Sum	−5.942	3.187	7.515	0.728	5.488

Table A3. The logarithmic mean divisia index (LMDI) analysis of maize virtual water trade (VWT) change in South Korea (million m^3).

Year	VWT Change				
	Water Intensity Effect	Product Structure Effect	Economic Effect	Population Effect	Total Effect
1992–1993	−607.030	−746.528	464.521	52.897	−836.140
1993–1994	−1299.143	−499.564	767.359	49.478	−981.869
1994–1995	−256.183	2224.647	961.826	50.804	2981.095
1995–1996	−428.308	−281.407	350.284	51.675	−307.756
1996–1997	−772.050	−284.875	−376.874	45.364	−1388.435
1997–1998	2503.413	−577.816	−1869.373	33.441	89.665
1998–1999	−1063.659	457.768	1295.248	36.301	725.658
1999–2000	800.433	303.732	837.121	50.565	1991.851
2000–2001	1080.774	−124.054	−425.479	55.856	587.098
2001–2002	−49.865	61.984	1059.923	47.154	1119.195
2002–2003	−1583.085	−372.209	908.540	43.431	−1003.322
2003–2004	−1475.969	690.729	913.476	30.909	159.146
2004–2005	−1670.236	−294.704	1184.341	15.472	−765.126
2005–2006	−1337.207	389.555	774.451	35.707	−137.494
2006–2007	−446.624	336.559	682.837	33.712	606.484
2007–2008	−212.841	−178.111	−763.606	48.087	−1106.470
2008–2009	−63.589	−625.400	−605.839	28.583	−1266.244
2009–2010	−532.522	336.640	1029.648	27.389	861.156
2010–2011	−387.143	−333.444	486.940	44.876	−188.771
2011–2012	2548.623	−131.714	105.080	37.695	2559.684
2012–2013	2080.247	438.556	646.967	45.165	3210.935
2013–2014	−2439.698	657.557	773.281	66.282	−942.577
2014–2015	1723.407	−154.560	−188.226	55.616	1436.237
2015–2016	−1102.106	−321.435	209.782	43.388	−1170.372
2016–2017	−1868.444	−119.684	762.157	27.999	−1197.973
Sum	−6858.805	852.223	9984.385	1057.849	5035.652

Table A4. The logarithmic mean divisia index (LMDI) analysis of millet virtual water trade (VWT) change in South Korea (million m^3).

Year	VWT Change				
	Water Intensity Effect	Product Structure Effect	Economic Effect	Population Effect	Total Effect
1992–1993	4.939	5.006	0.778	0.089	10.811
1993–1994	2.078	3.467	2.189	0.141	7.875
1994–1995	−8.213	−3.920	2.552	0.135	−9.446
1995–1996	3.146	1.978	0.824	0.122	6.070
1996–1997	4.274	5.888	−1.281	0.154	9.036
1997–1998	0.716	−5.192	−6.152	0.110	−10.518
1998–1999	2.259	6.573	3.982	0.112	12.925
1999–2000	−1.277	−0.473	2.755	0.166	1.171
2000–2001	5.814	1.642	−1.343	0.176	6.289
2001–2002	−3.579	−5.078	3.288	0.146	−5.223
2002–2003	4.146	7.197	3.121	0.149	14.613
2003–2004	5.646	11.059	4.394	0.149	21.248
2004–2005	−19.097	−2.390	5.815	0.076	−15.597
2005–2006	−7.320	−2.678	3.140	0.145	−6.713
2006–2007	0.380	−0.392	2.785	0.138	2.910
2007–2008	0.602	−10.390	−3.331	0.210	−12.908
2008–2009	2.011	8.780	−2.840	0.134	8.084
2009–2010	−5.890	1.477	4.712	0.125	0.424
2010–2011	−0.053	0.429	2.150	0.198	2.724
2011–2012	−2.707	−7.278	0.378	0.136	−9.471
2012–2013	2.635	6.324	1.756	0.123	10.837

Table A4. *Cont*.

Year	VWT Change				
	Water Intensity Effect	Product Structure Effect	Economic Effect	Population Effect	Total Effect
2013–2014	−6.923	2.778	1.963	0.168	−2.015
2014–2015	5.836	1.944	−0.484	0.143	7.439
2015–2016	−3.035	0.579	0.552	0.114	−1.790
2016–2017	−4.205	−1.349	2.028	0.075	−3.451
Sum	−17.818	25.980	33.731	3.432	45.325

Table A5. The logarithmic mean divisia index (LMDI) analysis of wheat virtual water trade (VWT) change in South Korea (million m^3).

Year	VWT Change				
	Water Intensity Effect	Product Structure Effect	Economic Effect	Population Effect	Total Effect
1992–1993	1354.596	1854.659	639.481	72.821	3921.557
1993–1994	−184.664	513.094	1385.891	89.361	1803.682
1994–1995	−6380.430	−4526.095	1278.909	67.553	−9560.063
1995–1996	−816.860	720.019	274.650	40.517	218.327
1996–1997	3832.318	−159.414	−432.743	52.089	3292.249
1997–1998	3989.325	2385.183	−3180.983	56.905	3250.429
1998–1999	−6312.979	−539.804	1404.110	39.352	−5409.320
1999–2000	1874.252	−598.202	638.553	38.571	1953.174
2000–2001	941.557	694.489	−368.831	48.420	1315.635
2001–2002	−543.822	−188.712	885.389	39.389	192.244
2002–2003	−1097.870	52.914	742.321	35.485	−267.150
2003–2004	−1185.003	−934.053	759.655	25.704	−1333.697
2004–2005	−925.267	847.667	1029.912	13.455	965.766
2005–2006	−878.000	4.696	722.739	33.323	−117.242
2006–2007	−1402.439	−493.017	602.813	29.762	−1262.881
2007–2008	206.751	−170.006	−640.837	40.356	−563.736
2008–2009	2563.848	823.124	−658.564	31.071	2759.480
2009–2010	−723.538	−124.431	1386.186	36.873	575.091
2010–2011	−213.655	1199.589	668.491	61.608	1716.032
2011–2012	2436.285	135.460	139.596	50.076	2761.417
2012–2013	−2883.803	−748.426	636.141	44.409	−2951.679
2013–2014	−2472.775	−1622.239	566.428	48.552	−3480.035
2014–2015	93.458	459.425	−122.087	36.073	466.869
2015–2016	1161.917	242.855	143.775	29.736	1578.283
2016–2017	−946.935	−27.282	613.704	22.545	−337.968
Sum	−8513.733	−198.505	9114.700	1084.006	1486.468

Table A6. The logarithmic mean divisia index (LMDI) analysis of soybean virtual water trade (VWT) change in South Korea (million m^3).

Year	VWT Change				
	Water Intensity Effect	Product Structure Effect	Economic Effect	Population Effect	Total Effect
1992–1993	−519.141	−172.572	179.990	20.496	−491.227
1993–1994	−40.499	197.230	312.919	20.177	489.826
1994–1995	−163.546	−53.209	438.308	23.152	244.705
1995–1996	−150.758	−259.497	159.471	23.526	−227.258
1996–1997	395.669	655.005	−201.987	24.313	872.999
1997–1998	669.507	−284.496	−1021.950	18.282	−618.657
1998–1999	−520.108	−186.076	614.957	17.235	−73.992

Table A6. *Cont.*

Year	VWT Change				
	Water Intensity Effect	Product Structure Effect	Economic Effect	Population Effect	Total Effect
1999–2000	−270.094	122.014	350.468	21.169	223.557
2000–2001	−108.479	−331.901	−144.013	18.906	−565.487
2001–2002	−88.247	104.702	320.968	14.279	351.702
2002–2003	−206.297	311.265	286.564	13.699	405.230
2003–2004	−683.783	−94.853	292.173	9.886	−476.577
2004–2005	−175.520	−190.923	392.337	5.125	31.019
2005–2006	−608.297	−429.896	269.205	12.412	−756.577
2006–2007	−48.873	−142.459	235.512	11.627	55.808
2007–2008	656.322	474.829	−311.095	19.591	839.647
2008–2009	−232.660	351.712	−274.016	12.928	−142.035
2009–2010	−403.057	−377.530	429.247	11.418	−339.921
2010–2011	−227.085	−276.939	192.076	17.702	−294.246
2011–2012	2.115	44.161	33.961	12.183	92.421
2012–2013	−316.290	57.008	147.461	10.294	−101.526
2013–2014	136.035	378.471	171.518	14.702	700.727
2014–2015	123.230	−162.048	−45.517	13.449	−70.886
2015–2016	−38.167	133.108	50.034	10.348	155.323
2016–2017	−265.473	103.037	197.972	7.273	42.808
Sum	−3083.497	−29.856	3076.562	384.172	347.381

Table A7. The logarithmic mean divisia index (LMDI) analysis of sorghum virtual water trade (VWT) change in South Korea (million m^3).

Year	VWT Change				
	Water Intensity Effect	Product Structure Effect	Economic Effect	Population Effect	Total Effect
1992–1993	−148.371	−144.888	9.025	1.028	−283.207
1993–1994	−30.994	−23.221	5.134	0.331	−48.749
1994–1995	23.557	25.320	6.637	0.351	55.865
1995–1996	124.585	129.931	6.778	1.000	262.293
1996–1997	−110.068	−98.292	−9.023	1.086	−216.297
1997–1998	−57.064	−53.871	−7.589	0.136	−118.388
1998–1999	1.656	2.539	0.824	0.023	5.043
1999–2000	−1.854	−1.501	0.553	0.033	−2.769
2000–2001	0.958	0.087	−0.220	0.029	0.854
2001–2002	−0.484	0.099	0.546	0.024	0.185
2002–2003	−0.123	−0.186	0.481	0.023	0.194
2003–2004	119.718	60.198	4.374	0.148	184.438
2004–2005	−130.400	−45.013	6.050	0.079	−169.284
2005–2006	−1.252	−1.217	0.480	0.022	−1.967
2006–2007	8.863	7.450	0.788	0.039	17.140
2007–2008	−9.313	−9.809	−0.884	0.056	−19.951
2008–2009	0.993	2.470	−0.403	0.019	3.079
2009–2010	−0.931	0.004	0.733	0.020	−0.174
2010–2011	1.256	1.171	0.385	0.035	2.848
2011–2012	−0.297	−0.416	0.079	0.028	−0.605
2012–2013	0.139	0.407	0.363	0.025	0.936
2013–2014	−1.316	−1.582	0.395	0.034	−2.469
2014–2015	−0.385	−0.122	−0.084	0.025	−0.566
2015–2016	−0.113	0.322	0.086	0.018	0.314
2016–2017	−1.167	0.091	0.311	0.011	−0.754
Sum	−212.405	−150.030	25.821	4.623	−331.991

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