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ANALYZING GLOBAL CROP TRADE PATTERNS AND REGIONAL DIFFERENTIATION IN THE FACE OF CLIMATE CHANGE: A CLUB CONVERGENCE APPROACH

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Abstract

Given the impacts of global climate change, foreign trade in crops is likely to face a number of challenges. It is therefore necessary to assess the foreign trade of crops from a global perspective. This study employs the club convergence analysis by Phillips and Sul to understand the extent to which export markets of crops are differentiated across countries and the differential impact across product groups. The analysis considers codes 6-14 of the 2-digit internationally harmonized system classification, which covers crop exports of countries over the period 1990-2022. The results of the analysis show that crop exports are regionally differentiated between coastal and continental regions, with 10 countries acting distinctively with other country groups in different product groups, clearly demonstrating the differentiation between countries. In addition, the study examines wheat-grain exports as a case study. We observed that most countries with significant shares in wheat-grain production and trade are in the same clubs, that is, they act together.

Key words**:** *crop export, climate change, club convergence, panel data*

INTRODUCTION

As of 2022, the agricultural sector accounted for 4.3 percent of the world's Gross Domestic Product (GDP) and the value added in agriculture reached 3.8 trillion USD. According to projections, the fact that the human population will reach 9.7 billion by 2050, and that the increasing population will fuel the need for food, draw attention to agricultural food products. On the other hand, the fifth report of the Intergovernmental Panel on Climate Change (IPCC) predicts that people will be under significant risks if climate change continues (IPCC). The report states that people will be exposed more to climate change-induced heat waves, food and water shortages, fires and vector diseases [6].
Potential problems stemming from climate change are expected to affect the foreign trade of crops. Two important events in recent history can serve as a source of inspiration for finding solutions to potential problems in foreign trade markets of crops. The first one is the foreign trade problem of medical products during the Covid-19 pandemic, and the other is the problem of grain shipment during the Ukraine-Russia war. For the former, after Covid-19 was declared as a pandemic, countries quickly banned foreign trade of medical products and tried to stabilize the domestic market by taking specific measures (production of drugs, distribution, price ceilings, etc.) to address the panic-induced increase in demand. The development of the Covid-19 vaccine and the containment of the pandemic enabled the supply of medical products, especially vaccines, to the countries where the pandemic continued. In the second case, the Grain Corridor Agreement was signed to prevent a global food crisis in the wake of the Russian-Ukrainian War. Thanks to the coordination made possible by Türkiye and the United Nations, grain products were made available to international markets, thereby preventing the increase in the prices of agricultural products. In the case of Covid-19, countries initially acted independently, but

after their own individual interests were satisfied, they started to act jointly. In the second case, it became necessary for all parties to act in line with their common interests, as the foreign trade of agricultural food products was in question. In this context, considering the inevitable effects of climate change, it may be necessary for countries to act together in line with their common interests in foreign trade of crops.

The purpose of this study is to investigate the extent to which foreign trade markets for crops are differentiated by country and the differential impact across product groups. The Phillips and Sul club convergence analysis is utilized for this purpose. This is the first study to examine countries that exhibit similar trends in exports of crops in terms of sub-clubs by product groups. Such an analysis provides a basis for discussing policy efforts to address the vulnerability of crop exports in extreme circumstances. In this respect, the study stands out from the existing literature. On the other hand, the study employs a new approach to club convergence analysis. In addition, the study analyzes the exports of wheat-grain products as a case study [12; 13].

In the remainder of the study, Section 2 presents the theoretical framework, while Section 3 introduces the dataset and methodology. Section 4 presents the empirical findings and Section 5 provides a visualization of the analysis results. Section 6 concludes the study.

Theoretical framework

The main motivation of the study is the hypothesis of club convergence in exports, that is, whether countries act together in the exports of crop products. The convergence hypothesis is based on Solow's neo-classical growth theory which assumes that capital is subject to diminishing returns [17]. Solow argued that in the initial phase, poor countries will grow faster than rich countries and thus poor countries will converge to rich countries. The key measures in the convergence hypothesis are absolute (unconditional) β-convergence, conditional β-convergence and club convergence. The absolute and conditional convergence emphasize that the per capita income of countries/regions will converge in the long run regardless of initial conditions [17]. However, in the case of club convergence, clubs with a particular equilibrium emerge for country/countries with similar structural characteristics and behaviors [2].

Existing studies in the literature on crop/agricultural convergence focus on agricultural productivity and agricultural income and employ absolute and conditional convergence methods. Among the studies on this subject, Lusigi et al. investigated the convergence of per capita income from agriculture and total factor productivity for thirty-two countries in Africa and concluded that education and investment are the most significant convergence conditions [9]. Rezitis explored whether there is convergence in agricultural total factor productivity between the US and nine European countries and found that convergence is valid [15]. Ghosh studied regional convergence in agricultural development in fifteen major agricultural states in India. According to conditional β-convergence, there are significant differences in land, labor productivity and agricultural output per capita. Factors such as human capital, physical capital, rural infrastructure, and population living in rural areas account for these differences [4]. Galonopoulos et al. examined the convergence of agricultural productivity among a group of thirty-two countries using absolute, conditional β-convergence and club convergence [3]. The club convergence analysis revealed that there are two separate clubs among the countries. In another study using club convergence analysis, Zhan et al. found that the club convergence hypothesis is valid for twenty-nine provinces of China [20].

Barath and Fertöanalyzed agricultural productivity for twenty-three EU Member States with β and σ convergence. The authors found that the convergence hypothesis is valid for agricultural total factor productivity, but the rate of convergence was rather slow [1]. Kijek et al. studied the convergence hypothesis in the old (EU-15) and new (EU-10) EU Member States using agricultural total factor productivity for the period 2004-2016. The researchers found that the convergence

hypothesis is valid in EU countries except Belgium and the United Kingdom. In addition, the convergence in the agricultural productivity of the new EU member countries was found to be faster than that of the old EU Member States [7]. McCunn and Huffman analyzed the conditional β-convergence in agricultural productivity for 42 US states [10], Mukherjee and Kuroda for 14 major states of India [11], Rezitis for the US and nine European countries [16], and Gong for China [5], but not σ-convergence. Poudel et al. investigated global agricultural convergence for forty-eight states in the US [14] and Yuan et al. found that the convergence hypothesis is not valid [18]. As can be seen from the existing literature, there is no study investigating the convergence of crop exports. It is also worth noting that the studies on club convergence are quite limited [13; 8].

MATERIALS AND METHODS

The crop export data of the countries analyzed in the study cover the period 1995-2022. These data are codes 6, 7, 8, 9, 10, 11, 12, 13 and 14 in the 2-digit internationally harmonized system (HS-2) classification and were retrieved from the COMTRADE database. Table 1 shows the descriptive information of the data.

Table 1. Descriptive Information of the Data

HS Code	Description	Countries
6	Live trees and other plants; bulbs, roots and the like; cut flowers and ornamental foliage.	89
7	Edible vegetables and certain roots and tubers.	95
8	Edible fruit and nuts; peel of citrus fruit or melons.	96
9	Coffee, tea, maté and spices.	97
10	Cereals	86
11	Products of the milling industry; malt; starches; inulin; wheat gluten.	92
12	Oilseeds and oleaginous fruits; miscellaneous grains, seeds and fruit; industrial or medicinal plants; straw and fodder.	93
13	Lac, gums, resins and other vegetables aps and extracts	73
14	Vegetable plaiting materials; vegetable products not elsewhere specified or included.	67

Source: World Customs Organization, 2024, Hs Nomenclature 2007 Edition [19].

The methodology proposed by Phillips and Sul was employed to analyze the convergence of crop exports [12]. The methodology proposed by Phillips and Sul is based on a non-linear transition model and explores convergence with respect to idiosyncratic time varying components:

$$Y_{it} = \partial_{it}\mu_t \qquad (1)$$

In Model 1, Y_{it} represents the crop exports of countries by HS-2 code, ∂_{it} represents the components of time varying units, and μ_t represents the time varying common factor in the data. ∂_{it} cannot be estimated directly through Model 1.
Therefore, the components of the units are defined as in Model 2:

$$\partial_{it} = \partial_i + \sigma_i v_{it} L(t)^{-1} t^{-a} \qquad (2)$$

In Model 2, ∂_i is the constant, v_{it} iid(0,1) is the weak dependence on t along i, σ_i is the measurement parameter, a is the convergence rate, and L(t) is the slowly varying penalty function. In this model, ∂_{it}, converges to ∂_i for a ≥ 0. Therefore, the hypothesis H_0 ($H_0 = \partial_i = \partial$ and a ≥ 0) indicating whether there is convergence in the panel is tested against the alternative hypothesis H_1 ($H_1 = \partial_i \neq \partial$ and a < 0). To test the hypothesis H_0 in the panel, Phillips and Sul show the relative transition parameter as in Model 3 [12]:

$$h_{it} = \frac{Y_{it}}{\frac{1}{N}\sum_{i=1}^{N} Y_{it}} = \frac{\partial_{it}}{\frac{1}{N}\sum_{i=1}^{N} \partial_{it}} \qquad (3)$$

In Model 3, h_{it} is the transition parameter of country 'i' relative to the panel average at time t. The convergence $t \rightarrow \infty$ occurs as h_{it} moves to 1 for all 'i's. The convergence concept defined in the model can be expressed as h_{it}, where H_t represents the horizontal cross-section variance:

$$H_t = \frac{1}{N}\sum_{i=1}^{N} (h_{it} - 1)^2 \qquad (4)$$

In Model 4, if the cross-sectional distribution of h_{it} or ∂_{it} decreases, the inverse variance ratio (H_1/H_t) will increase over time. For this reason, Phillips and Sul proposed the logt convergence test [12]:

$$\log\left(\frac{H_1}{H_t}\right) - 2logL(t) = \hat{a} + \hat{b}log(t) + \hat{\varepsilon}_t, for\ t = [rT], [rT] + 1, \dots, with\ r > 0 \qquad (5)$$

In Model 5, H_1/H_t is the horizontal cross-section variance ratio, $\hat{b} = 2\hat{a}$ is the speed of convergence parameter, -2log L(t) is the penalty function that improves the performance of the test, r is the parameter that removes a certain number of initial observations, and the choice of r directly affects the results. Based on Monte Carlo simulation experiments in the log-t test, Phillips and Sul states that taking r as 1/3=0.33 for small samples (T≤50) and 1/5=0.2 for large samples would yield better results [12]. However, Kwak found that 1/10 = 0.1 for small samples outperforms the 0.33 suggested by PS at p = 0.05 significance level [8]. In addition, when T is very small in the log t test, the size of Y_{it} is distorted if r is taken as 0.33, but the size of Y_{it} is not distorted if r is taken as 0.1 [8]. To test the hypothesis of convergence H_0, the one-sided t-statistic using standard errors consistent with changing variance and autocorrelation is utilized. The hypothesis H_0 is rejected if the one-sided t statistic is less than -1.65.

RESULTS AND DISCUSSIONS

According to the 2-digit Harmonized System classification, codes HS-06 to HS-14 correspond to crop products. Table 2 shows the log t results for the whole panel for these crop products.

Table 2. Crop Export Club Log t Results

HS Code	6	7	8	9	10	11	12	13	14
Coefficient	-1.242	-1.211	-1.178	-1.038	-1.205	-1.143	-1.245	-1.133	-1.345
T statistics	-4.941	-3.983	-4.205	-3.116	-4.161	-4.206	-4.467	-4.343	-6.113

Source: Own calculation.

As the log t values calculated for the 9 product groups in Table 2 are smaller than the critical the combined final club results at the last phase.

An analysis of Table 3 reveals that exports of HS-06 to HS-10 are divided into 12, 9, 8, 5 and 6 sub-clubs, respectively. In 5 product groups, Italy and Germany stand out as being in the first club. Subsequently, the Netherlands, South Africa and Belgium act together in club 1 with 4 product groups. On the other hand, Ecuador, Tunisia and Saint Vincent and the Grenadines are in the last club in all 5 product groups and have the same transition paths. It can also be observed that there are diverging countries that do not belong to any club in the exports of crop products; namely Chile and Poland for HS-6; the Netherlands for HS-07; Barbados, Estonia, Jordan and El Salvador for HS-08; and Austria, Barbados, Canada and Denmark for HS-10.

Table 3. Crop Export Club Convergence (6-10)

CLUB/HS	6	7	8	9	10
C1	BFA CYP DEU DNK GBR ITA JPN NLD PRT ZA1	AUS, BEL, BGR, DEU, DNK, EGY, ITA, NZL, PRT, ZA1	AUS, BEL, BFA, CHL, DEU, EGY, GRC, GRD, HKG, ITA, NLD, NZL, PRT, SVK, TGO, TTO, ZA1, ZMB	BEL, BGR, BRA, CAN CHE, CHN, COL, CZE DEU, FRA, GBR, GTM IDN, IND, ITA, JOR, JPN, LTU, MDG MEX, MUS, NIC, NLD, PER, POL, RUS SVK, SVN, TUR, USA	BEL, BGR, DEU, GRC, ITA, LVA, NLD, SEN, SVK, SWE, ZA1
C2	EGY GRC IRL MAR NZL	CHL, CYP, IRL, JPN, LVA, MWI, OMN, SVK, SWE	BLZ, DNK, FIN, GBR, IRL, SVN, SWE, USA	ARG, AUS, AUT, AZE, BOL, CHL, CRI, DNK, EGY, EST, FIN, GEO, GRC, GRD, HKG, HRV,	ARG, BFA, BRA, CHE, CHL, CYP, CZE, EGY, EST, FIN, GBR, GUY, HKG, HUN, IRL, JPN, LTU,

				HUN, IRL, ISR, LVA, MAR, MDA, MKD, MOZ, MWI, MYS, NOR, NZL, PRT, PRY, SAU, SEN, SGP, SLV, SWE, THA, UKR, ZA1	MEX, MLT, MWI, NOR, NZL, OMN, POL, PRT, PRY, ROU, SVN, THA, TTO, UKR, URY, USA, ZMB
C3	BEL CAN FIN SEN SVK	GRC, SVN	AZE, BDI, BOL, BRA, CHE, CYP, CZE, GEO, GTM, HRV, ISL, ISR, LTU, MDA, MEX, MOZ, MUS, MWI, NOR, PER, POL, PRY, SYC, TUR, UKR	CYP, PYF	BOL, HRV, MDA, MUS, TGO, TUR
C4	AUS MKD NOR PER SVN	FIN, HKG, MEX	CAN, JPN	BLZ, GUY, ISL, URY	COL, GEO, GTM, ISR, MKD, MOZ, NIC, PHL, SLV
C5	CHE ETH LVA SGP SWE	CAN, CHE	BGR, HUN	BDI, CIV, COM, ECU, ETH, JAM, KAZ, KOR, LCA, MAC, MLT, NER, OMN, PAN, PHL, ROU, SYC, TGO, TTO, TUN, UGA, VCT, ZMB	AUS, CHN, CIV, CRI, ECU, ETH, FRA, IDN, IND, KAZ, KOR, MAR, MDG, MYS, NER, PER, RUS, SAU, SGP, TUN, UGA, VCT
C6	CRI CZE GTM HKG HUN ISR KAZ LTU MEX MWI PYF SLV SUR TUR USA	ARG, AZE, BLZ, BOL, BRA, CRI, CZE, EST, GEO, GTM, GUY, HRV, HUN, ISL, ISR, JOR, KOR, LTU, MDA, MKD, MOZ, MUS, NIC, NOR, PER, POL, ROU, SLV, SUR, TGO, TUR, UKR, USA	MKD, NIC, PAN, ROU, URY		Not Convergent AUT, BRB, CAN, DNK
C7	BRA GEO HND HRV ISL KOR MDA NIC PHL PRY UKR	PRY, URY	ARG, AUT, CHN, CIV, COL, CRI, ECU, ETH, FRA, GMB, IDN, IND, JAM, KAZ, KOR, LCA, LVA, MAR, MDG, MLT, MYS, NER, OMN, PHL, RUS, SAU, SEN, SGP, THA, TUN, UGA, VCT		
C8	COL EST JOR	CIV, GBR	Not Convergent BRB, EST, JOR, SLV		
C9	MUS URY	AUT, BDI, BFA, CHN, COL, ECU, ETH, FRA, IDN, IND, JAM, KAZ, LCA, MAC, MAR, MDG, MLT, MYS, NER, PAN, PHL, RUS, SAU, SEN, SGP, THA, TTO, TUN, UGA, VCT, ZMB			
C10	BGR BRB UGA	Not Convergent NLD			
C11	ARG AUT BDI CHN CIV ECU FRA IDN IND JAM LCA MDG MYS OMN PAN ROU RUS SAU THA TTO TUN VCT ZMB				
C12	Not Convergent CHL POL				

Source: Constructed by the authors using club convergence methodology.

Table 4. Crop Export Club Convergence (11-14)

CLUB NO/HS	11	12	13	14
C1	AUS, BEL, BGR, CAN, CHE, CYP, DEU, DNK, EGY, FIN, GBR, GRC, GRD, GUY, HKG, IRL, ITA, JOR, JPN, LVA, MUS, NLD, NOR, NZL, PRT, SEN, SUR, SVK, SWE, ZA1	AUS, AUT, BEL, BGR, CAN, CYP, DEU, DNK, EGY, GBR, HKG, IRL, ITA, NZL, OMN, PRT, SEN, SVK, ZA1	BEL, BGR, CAN, CHE, CYP, DEU, DNK, EGY, FIN, GBR, GRC, HKG, IRL, ITA, JPN, MDG, MYS, NLD, NZL, PRT, SGP, SVK, ZA1	BEL, BGR, CAN, CHE, DEU, EGY, GBR, GRC, HKG, IRL, ITA, JPN, NZL, PRT, SWE, ZA1
C2	BFA, BRA, CZE, EST, GTM, HRV, HUN, ISL, KOR, LTU, MDG, MEX, MOZ, MWI, PRY, SLV, TTO, TUR, UKR, URY, USA	BRA, FIN, GRC, ISL, JPN, MUS, NOR, SVN, SWE, UKR, USA	BRA, CHL, CIV, CZE, GTM, HRV, ISR, JOR, KOR, LTU, MEX, MKD, MLT, NOR, PHL, POL, SVN, TTO, TUR, USA	AUS, SVK
C3	BRB, CRI, GEO, ISR, MDA, NIC, TUN	CHL, CZE, GUY, HRV, HUN, LTU, MDA, MOZ, POL, PRY, TTO, TUR, URY, VCT	AUS, SWE	MEX, SVN
C4	BOL, MKD	ISR, KAZ, MEX, NIC, PER	COL, EST, ETH, GEO, HUN, SLV, UKR, URY	DNK, NLD
C5	ARG, AUT, CHN, CIV, COL, ECU, ETH, FRA, IDN, IND, JAM, KAZ, LCA, MAR, MLT, MYS, NER, OMN, PER, PHL, ROU, RUS, SAU, SGP, TGO, THA, UGA, VCT, ZMB	BLZ, BOL, GTM, UGA	ARG, AUT, BOL, CHN, CRI, ECU, FRA, IDN, IND, KAZ, LVA, MAR, PER, ROU, RUS, SAU, SEN, THA, TUN, UGA	AZE, BRA, CHL, CZE, GTM, HUN, JOR, LTU, MDA, NOR, POL, TUR, UKR, USA
C6	Not Convergent CHL, POL, SVN	CHE, EST, JOR		BOL, EST, ETH, GEO, HRV, NIC, SLV
C7		AZE, GEO, MKD, PAN, SLV		FIN, KAZ
C8		ARG, BDI, BFA, CHN, CIV, COL, CRI, ECU, ETH, FRA, GMB, IDN, IND, JAM, KOR, LVA, MAR, MDG, MLT, MWI, MYS, NER, PHL, ROU, RUS, SAU, SGP, TGO, THA, TUN, ZMB		AUT, CHN, CIV, COL, CRI, ECU, FRA, IDN, IND, KOR, LVA, MAR, MDG, MYS, PER, PHL, ROU, RUS, SGP, THA, TUN, UGA
C9		Not Convergent NLD		

Source: Constructed by the authors using club convergence methodology.

The results of the export analysis of products from HS-11 to HS-14 are presented in Table 4. An analysis of Table 4reveals that countries are divided into 6, 9, 5 and 8 sub-clubs in the exports of products from HS-11 to HS-14, respectively. Countries with different geographical regions such as Belgium, Bulgaria, Germany, United Kingdom, Portugal, Ireland, Italy, Canada, South Africa, Hong Kong, New Zealand and Egypt are in club 1 in all 4 product groups and have the same transition paths. It is noteworthy that the majority of these countries are located in the European continent. In addition, China, Indonesia, India, Thailand, Thailand, Russia, Romania, Morocco, Ecuador and France act together in the last club. As in Table 3, Table 4 shows that there are countries that do not belong to any club in crop exports including Chile, Poland and Slovenia for code 11 and the Netherlands for code 12.

Visualization of the results

The present study employs Gephi 0.10, a network analysis application, to visualize the results. Gephi 0.10 is an open source network analysis application that can be used to reveal complex network relationships. The reason for choosing Gephi 0.10 is that it is more adaptable and has better visualization features than other available network software packages. Each country is defined as a "node" in the graphs, and countries in a common club are defined as "edges". Since countries are not in the same club, the links are weighted and directed. Direction-weighted graphs are generated using the club as convergence speed weights. The geography-based network is spatialized in the visualization using Geo-Layout, a geographic layout method. The geographic coordinates (latitude and longitude) of each country were placed in the Gephi.

Figure 1 includes 4 graphs: Panel A, Panel B, Panel C and Panel D. In Panel A, each color indicates a sub-club, while in Panel B each

sub-club is shown as a single club. The red club in Panel B, which is clearly shown in Panel C, represents the countries that do not belong to any club in exports of crop products. The lines in panels A, B and C show the social networks linking countries and the sub-clubs they belong to. The countries that do not belong to any club are marked on the world map in Panel D, which shows that non-converging countries located on three continents.

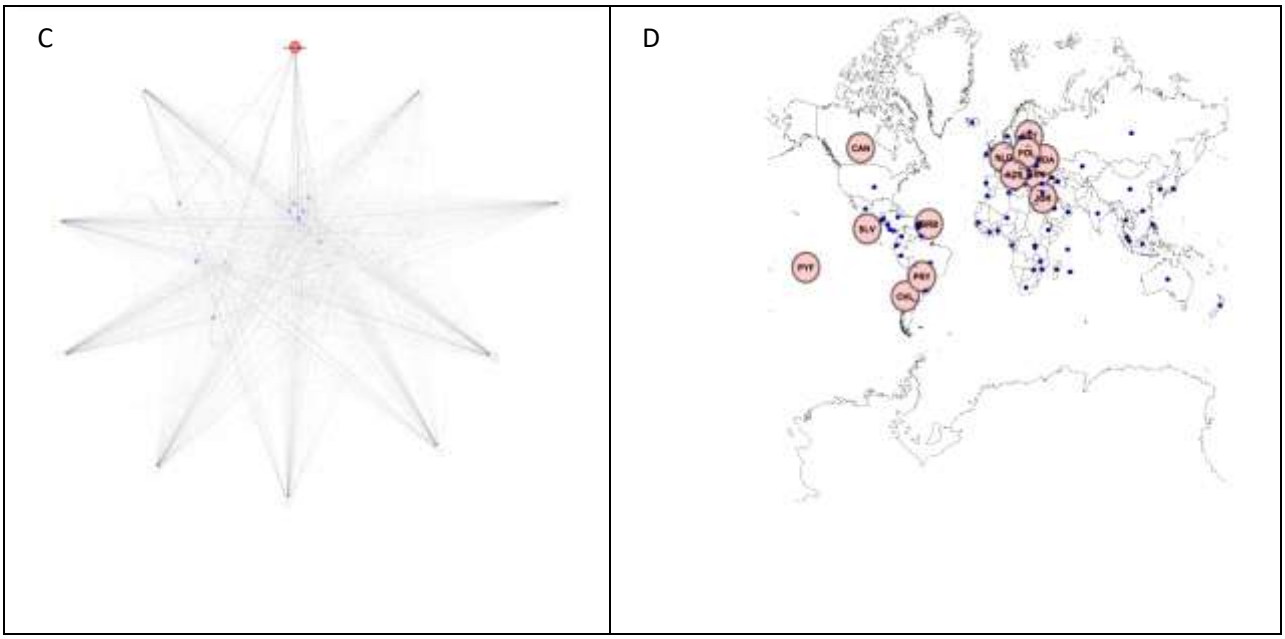


Fig. 1. Countries Not Included in Convergence
Source: Generated by the authors.

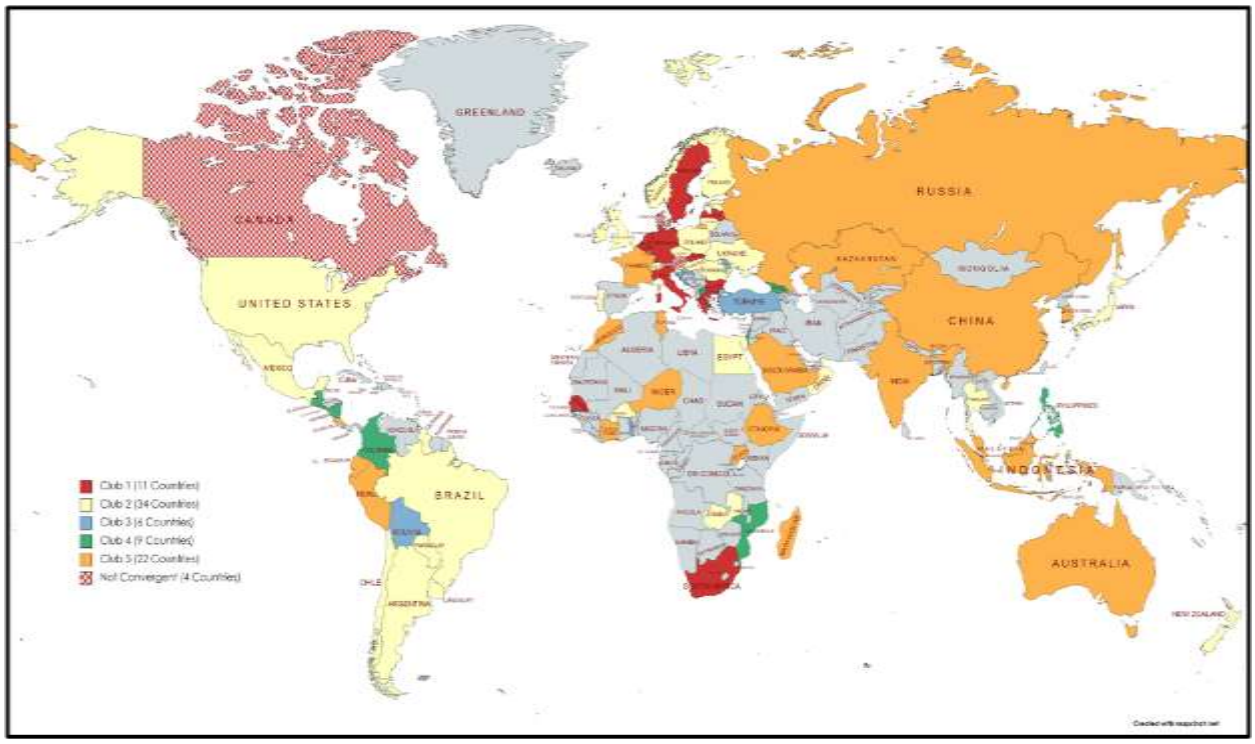
Case study

The Covid-19 pandemic, which broke out at the end of 2019, spread across the world in 2020 and started to show its impacts. As of 2020, the demand for grain and grain products increased due to their ability to be stored and preserved for extended periods of time, leading to a significant increase in world grain use and stocks. Before the world could fully recover from the Covid-19 pandemic, the war between Russia and Ukraine which started on 24 February 2022 negatively affected the whole world in terms of agricultural products supply.

On the one hand, due to the prolonged war between Russia and Ukraine, which has an important position in the world grain supply, and the economic sanctions imposed on Russia due to the war, and on the other hand, due to the Covid-19 outbreak, prices, which had been on an upward trend, increased further and reached record levels. Russia and Ukraine, which are considered to be the granaries of the world, are among the most active countries in the world grain trade. These countries are net exporters of several grain products. Both the impact of Covid-19 and the Russian-Ukrainian war forced countries to act together to solve the problems caused by the excessive increases in the prices of commodity-energy-grain products as well as challenges in their supply. It will be important to know which countries or groups of countries can or cannot come together in the face of the circumstances that have occurred or are likely to occur. For the common interests of producer-exporter or importer countries in the trade of grain products, countries can be expected to act together rather than individually. The analysis included data from 86 countries in the trade of grain products.

According to the results in Table 2, the countries that export Wheat-Grain in HS-10 are divided into 5 clubs and there are 4 countries (Austria, Barbados, Canada and Denmark) that are not members of any club. It is seen that the top 10 countries in the world

wheat-grain exports are included in two different groups. Map 1 was generated by utilizing Table 2.



Map 1. Visualization of the Clubs for Grain Exports
Source: Visualized by the author.

Map 1 shows that the countries that are not in the top 10 in world wheat and grain production are mainly gathered in clubs 1, 3 and 4, while the countries that have an influence in the production and trade of wheat and grain products are in clubs 2 and 5. Countries in Club 2 (with the exception of Russia) are known to have an influence in the production of grain products and it is known that the majority of the production is consumed domestically. The countries in Club 2 (Russia, China, India and France) have been interpreted as countries that act independently by prioritizing their own national interests in order to maintain their strategic advantages and achieve new ones. In addition, the majority of the countries that have a significant share in world wheat-grain production and trade are gathered in club 5.

CONCLUSIONS

After 2000, structural transformations in the global agricultural sector, such as higher yields, relatively lower costs, a shift from staple food products to intermediate inputs, and a shift in production from low value-added to high value-added products, have created a more favorable market for international trade in agricultural products. This market needs to be stable on both the supply and demand sides to be sustainable. However, the impacts of global climate change, which have become more pronounced in recent years, are likely to cause a number of problems in the foreign trade of crops, primarily on the supply side. The PS (2007, 2009) club convergence analysis was employed in this study in order to identify the countries that may stand out in the vulnerability of crop exports in the event of possible extraordinary circumstances. The reason behind the choice of Phillips and Sul analysis was to identify whether countries act together in foreign trade of crops. The results of the analysis show that ten countries (Chile, Poland, the Netherlands, Barbados, Estonia, Jordan, El Salvador, Austria, Canada, Denmark, Slovenia) act separately from other country groups and clearly reveal the

differentiation between countries. Of these countries, Barbados, Jordan, Estonia, Slovenia and El Salvador have low export volumes, while Poland, the Netherlands, Austria, Canada and Denmark have high exports of certain product groups [12].

The literature review reveals that there are numerous studies investigating the convergence of macroeconomic indicators, but there is no convergence/divergence study examining crop exports. The focus of the present study is to investigate the convergence in the transfer of countries' exports to the world economy through their export volumes instead of their production volumes. In terms of methodology, the study employs a panel convergence methodology instead of examining annual changes in exports or other similar measures of distribution. While it is known that the market for crop products is heterogeneous across the world, given the large differences in the capacity of countries to produce crop products, it is highly unlikely that countries can act together in export markets. However, considering the results of the analysis performed in this study, it can be interpreted that countries can act jointly. This suggests that countries should consider establishing crisis management mechanisms to respond to future shocks such as climate change in a coordinated manner.

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