chemistry proceedings

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Social Network Analysis on Agricultural International Trade: A Study on Soybean, Soybean Cake and Maize Exports†

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† Presented at the 1st International Online Conference on Agriculture - Advances in Agricultural Science and Technology (IOCAG2022), 10–25 February 2022; Available online: https://sciforum.net/event/IOCAG2022

Abstract: World agriculture market is highly competitive, hence, the use of new approaches to analyze it can provide new insights to understand the factors that determine its competitiveness. This paper aims to investigate the global trade of soybean, soybean cake, and maize. They are listed among the most important commodities worldwide. To do so, we collected 2019 exports of these items from FAO database and analyzed them using Social Network Analysis (SNA) method. The results showed the following scenarios: Soybeans presents high competition between Brazil and the US and China is a shift factor being responsible for 67% of imports; Soybean cake shows the market with a larger number of buyers, however, Argentina, Brazil, and the US are the main exporters. Brazil and Argentina compete more in Europe and Asia countries, while the US mostly supplies its neighbours, Mexico and Canada; Maize demonstrated the same main exporter players that soybean cake: Brazil, Argentina and the US. Brazil and Argentina compete mainly in European and Asian markets, while the US mostly supplies its neighbours, except for Japan.

Keywords: international trade; agriculture commodities; grains; oilseeds

Citation: Lastname, F.; Lastname, F.; Lastname, F. Title. *Chem. Proc.* **2022**, *1*, 0. https://doi.org/

Published:

1. Introduction

The world trade of agricultural products has been growing every year, with a great impact on the global economy. Data shows that world trade has grown at an average of 3.3% per year since 2015 raising from US$ 1.2 trillion in 2015 to US$ 1.4 trillion in 2019 (13.6% increase) [1]. The main agricultural products traded in 2019 were maize, wheat, soybean, soybean cake and palm oil. These products represent almost 40% of all agribusiness exports in metric tons [1].

Due to the advances in cultivation methods and significant improvements in logistics systems, agribusiness, and, in particular, the grain market was gradually growing and diversifying its players. According to Sanguinet et al [2], after 1994, agricultural trade became part of the World Trade Organization (WTO) rounds. This led to an intensification of international bilateral and multilateral trade.

Complex systems, such as agribusiness exports are difficult to fully understand, so it is important to consider different approaches and tools. Mendes dos Reis et al [3] analyzed soybean exports using the Logistics Performance Index (LPI) and the gravity model approach. Sutrisno et al [4] used the Interpretative Structural Modeling (ISM) to analyze institutions that play a role in agribusiness systems. Kamilaris, Kartakoullis and Prenafeta-Boldu [5] studied the use of big data analysis in Agriculture.

Although these studies explore various aspects of agribusiness using different data analysis techniques, there are few studies that used Social Network Analysis (SNA) in the trade of agricultural products, and none related to global grain trade which reinforce the importance of this study.

SNA can contribute to understanding trade relationships in the agribusiness sector. In this study, we adopted SNA to understand trade relations over three important global commodities: soybean, soybean cake and maize. We seek to comprehend the connections between the main exporters and importers. These commodities are chosen because uses the same logistics infrastructure and are connected to human consumption and commercial animal production. The data analysis is conducted using UCINET and NetDRAW softwares and three SNA measures were adopted: centrality degree, K-core and volume of trade (line streght).

This paper is divided as follows: introduction address the article proposal and some background; methodology presents the procedures of the research; results section presents the findings of the research; discussion shows the implications and analysis; and finally the conclusion section points out the final remarks of the study.

2. Methodology

To conduct this study, the first step was data collection. We use the Food and Agriculture Organization of the United Nations (FAO) database to extract data on exports of soybean, soybean cake, and maize in the last year available (2019) [1]. The FAO database gathers information provided by the countries. The data represeting exports of these commodities in metric tons were exported to a CSV (Comma-separated values) file and later on organized using Microsoft Excel software.

Afterwards, we make some amendments to the data settings. Autonomous regions such as Taiwan, Hong Kong, and Macau were sum with mainland China. Moreover, we decided to establish a minimum value of 1,000 metric tones of trade. These adjustments had the purpose to avoid outlier data and fluctuations that cause a distortion in the analysis. Despite these minor modifications, our sample represents at least 90% of trade for three categories.

Besides that, we built a matrix with exporters in rows and importers in columns. The intersections represents the amount of metric tons traded. It was necessary to set the matrix as quadratic, in other words, all countries involved in the analysis have to be part of both the columns and the rows, even if they are not importers or not exporters.

To perform the data analysis the quadratic matrix was loaded into the UCINET 6.732 software from Analytic Technologies [6]. After, we transfer the data to NetDRAW 2.168 application [7]. This module convert data in a network graphic where the measures can be represented. The data type for the network was a 1-Mode Network and we set the options to ignore reflexive ties - ignore missing values and ignore zeros.

After that, we apply the Node Centrality Measures, setting node size by degree; and volume of exports [6]. Centrality degree is a centrality measure that represents the number of ties of a given type that a node has [8,9].

Another measure Applied was the k-core. A k-core is a subgraph in which every actor has a degree k or more with the other actors in the subgraph [10]. We also used the thickness of connections. This measure can be used to indicate the interaction frequency [9], the bond strength between the pairs [11] or the connection volume [8].

3. Results

3.1. Soybean

Figure 1 depicts the results of the soybean network. Green nodes mean exporters. Red nodes represent countries with a k-core of 3 or more, and blue nodes countries with a k-core of 1 or 2.

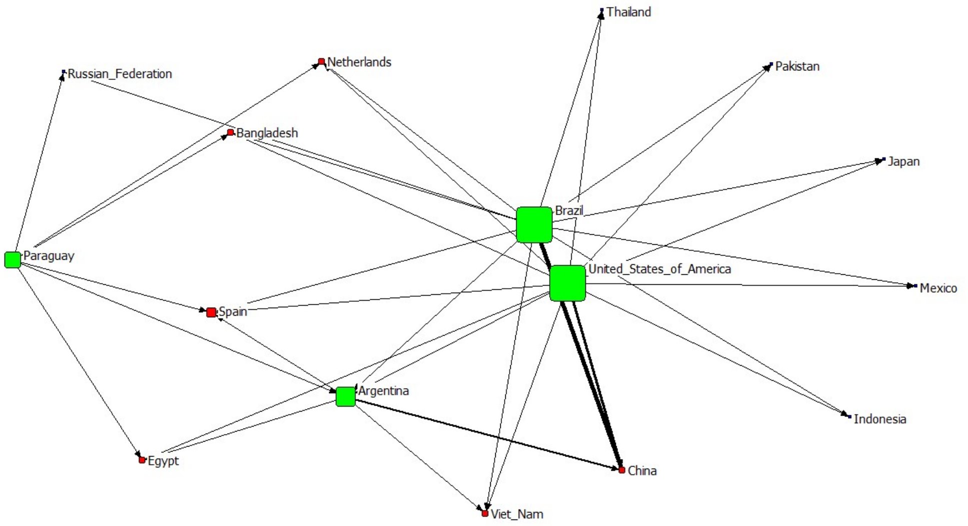

Figure 1. Soybean trade network.

The soybean market is highly concentrated, with few exporters and relatively few importers. Historically the US controlled the market until the 1970s. In the 1980s, Brazil and Argentina entered in the market configuring a concentrated market structure [2]. Brazil, the US, Argentina, and Paraguay represent more than 90% of exports, while only 12 countries represent 90% of imports [1]. It was possible to observe that there is fierce competition between Brazil and the US, where both compete directly on all importers. Mendes dos Reis et al (2020) show that the soybean market has a huge significance for exporters and, although the US has an advantage on hinterland logistics, the three main exporters have very similar trade costs as maritime freight and incoterms.

In this network, China is the biggest buyer representing 67% of the market. China presents a closer relationship with Brazil being the main importer of Brazilian products [12].

3.2. Soybean Cake

Figure 2 depicts the results of the soybean cake network. Blue nodes represent countries that have a k-core of 6 or more, black nodes represent countries that have a k-core of 5. Grey nodes have a k-core of 4. Pink nodes have a k-core of 3 and red nodes 2 or less.

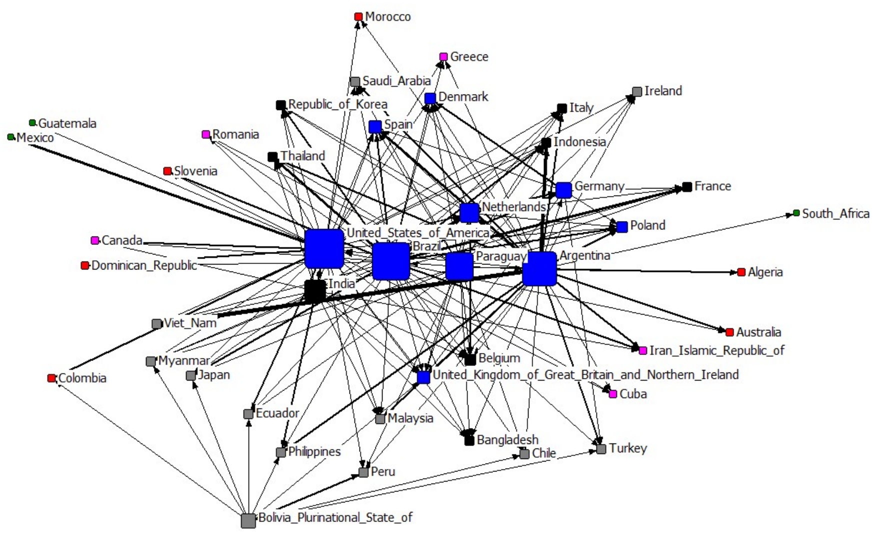

Figure 2. Soybean cake trade network.

The soybean cake market has a larger number of players. Argentina, Brazil and the US are the main exporters. In the number of connections, Argentina has an advantage, having 35 buyer countries (nodes), while Brazil and the US have 20 and 21 nodes, respectively. The results show that Brazil and Argentina compete more in Europe and Asia, while the US mostly supplies its neighbours, Mexico and Canada.

From the importer point of view, our study indicated that the Netherlands is an important importer for Brazil, and it is also an exporter for some European countries, indicating the country as a gateway for Europe, especially for Germany. A possible explanation for that is the dependency at some level of Brazil's soybean cake on Europe. Similar dependency also occurs on Vietnam and Indonesia related to the production of Argentina [13].

3.3. Maize

Figure 3 depicts the results of the soybean cake network. Blue nodes represent countries that have a k-core of 6 or more, black nodes represent countries that have a k-core of 5. Red nodes have a k-core of 4 and pink nodes 3 or less.

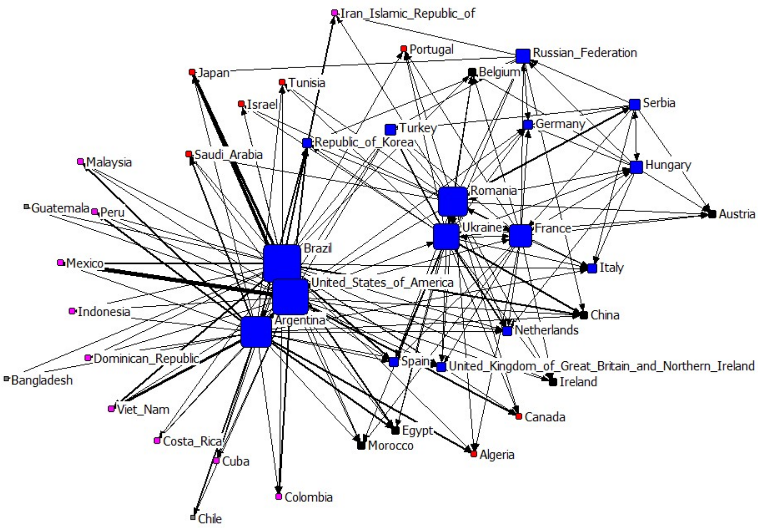

Figure 3. Maize trade network.

In the maize case, Brazil, Argentina, and the US have similarities in exports volume, with an advantage of a more diverse market of Brazil and Argentina over the US (33, 28, and 17 nodes, respectively). Brazil and Argentina compete mainly in European and Asian markets, while the US supplies its country neighbours, except for Japan. Burkholz and Schweitzer [14] studied the impact of a possible shock on Maize production from the US. The authors identified a special impact in Mexico and Japan as confirmed by our study.

Considering the consumption market, soybean presents a very peculiar result. China represents 67% of all demand. For comparison purposes, Mexico is in second place, but only has 3% of imports. Maize and soybean cake do not have the same results. For maize, the main markets are Japan, Mexico, and Vietnam, with much more balanced results (about 10%, 9%, and 7%, respectively). For the soybean cake market, the main importers are Vietnam, Indonesia, and the Netherlands (about 7%, 7%, and 4%, respectively) [1].

Regarding Brazil scenario, the agribusiness trade is essential to the country. According to data from Brazil's Ministry of Agriculture, Livestock and Supply (MAPA), agribusiness was responsible for almost half of Brazil's exports in 2020, with a 48% share, representing a trade balance surplus of US$ 87.76 billion [15].

The top five Brazilian agribusiness products exported year were the soybean complex (US$ 35.24 billion and 35% of exports), Meat (US$ 17.16 billion and 17% of exports), forest products (US$ 11, 41 billion and 11.3% of exports), sugar and alcohol complex (US$ 9.99

billion and 9.9% of exports) and cereals, fours and preparations (US$ 6.89 billion and 6.8% of exports) [15].

Argentina had similar results on agribusiness products exported. The top five were the soybean complex (US$ 15.23 billion and 42% of agribusiness exports), maize (US$ 5.9 billion and 16% of agribusiness exports), meat (US$ 3,0 billion and 8.3% of agribusiness exports), wheat (US$ 2.29 billion and 6.3% of agribusiness exports) and wine (US$ 792.73 million and 2.19% of exports) [1].

For the US, the top five were the soybean complex (US$ 22.89 billion and 16.3% of agribusiness exports), Food preparation (US$ 8.9 billion and 6.3% of agribusiness exports), maize (US$ 8,0 billion and 5.7% of agribusiness exports), wheat (US$ 6.26 billion and 4.4% of agribusiness exports) and cotton lit (US$ 6.14 billion and 4.3% of agribusiness exports) [1].

4. Conclusions

The world agribusiness market is growing and represent an important and strategic segment on countries exports and GDP. Like most complex systems, it is very difficult to study all aspects and characteristics of this trade using few techniques, tools or perspectives. It is therefore necessary to seek new perspectives and tools that enable new insights on the subject.

In this context, this work analyzed data from exports of soybean, soybean cake, and maize trade in 2019 obtained from FAO and analyzed them using Social Network Analysis method. It is possible to observe that social network analysis can be a relevant tool to analyze the global commerce of agricultural products, due to its capability of showing graphically a great amount of data. The method allows observing the connections between countries that play a role on the trade, along with the importance of each player and the trade volume, among other insights.

The results showed that the soybeans market is highly concentrated and presents high competition between Brazil and the US. China is the main importer, being responsible for 67% of imports. Soybean cake data shows a similar market competition, with Argentina, Brazil, and the US as the main exporters, the number of importers are much larger. Brazil and Argentina compete more in Europe and Asia countries, while the US mostly supplies its neighbours, Mexico and Canada. Maize demonstrated very similar data as soybean and soybean cake. Brazil, Argentina and the US are the main competitors. But different from soybean and similar to soybean cake, the market is much more diverse in the number of importers and a less concentrated market. Brazil and Argentina compete mainly in European and Asian markets, while the US mostly supplies its neighbours, except for Japan.

We suggest for further studies the use of the same method on different trade markets, searching for similar insights. Another approach could be the use of different measures and tools, along with the comparison of results across time, using the same method on different years.

5. Acknowledgements

The authors would like to thank you Capes for the financial support of this research.

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