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Exploring the Correlation between Brazilian Iron Ore Exports and the Chinese Construction Sector

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A B S T R A C T

This article investigates the international iron trade, focusing on the Brazil-China network and its implications for economic and social progress. Iron supports various industries, particularly construction, manufacturing, and infrastructure development. The study employs descriptive analysis, quantitative measures, and correlation coefficients to analyse the dynamics of the iron trade. The research highlights Australia and Brazil as significant exporters in the global iron ore market, with China as the primary importer. Network analysis reveals China's extensive commercial connections and strong trade relationships with key exporting countries. Correlation coefficients demonstrate positive associations between Brazil's Iron Exports, Brazilian GDP, Chinese construction sector GDP, and world construction sector GDP, emphasising their interdependence. Understanding these dynamics is essential for policymakers, economists, and industry stakeholders in navigating the complexities of the global economy. The study provides valuable insights into the international iron trade, its impact on the construction sector, and broader economic dynamics. It contributes to informed decision-making and promotes sustainable economic and social development.

1. Introduction

Iron is an indispensable foundational resource crucial for economic and social progress. Its indispensability stems from its fundamental role in supporting various facets of development. From an economic perspective, Iron is a cornerstone for industries such as construction, manufacturing, and infrastructure, enabling growth, innovation, and job creation. On a social level, Iron is vital in providing essential goods and services that improve living standards and enhance the overall quality of life. Therefore, recognising the pivotal significance of Iron as a critical resource is paramount in understanding and promoting sustainable economic and social development (Qiangfeng et al. 2018, Kesler & Laznicka 1994).

The escalating global significance of international iron ore trade has recently garnered increasing attention. This heightened focus can be attributed to the rapid growth witnessed in emerging economies, most notably China, which has experienced an unprecedented surge driven by substantial demands for steel and iron resources. Consequently, this unprecedented surge in demand has resulted in a remarkable upswing in the price of iron ore, thereby necessitating a deeper examination of the multifaceted dynamics and implications of this pivotal global trade (Wang 2011). Iron is one of the most exported items from Brazil to China (Carina Roberta et al. 2016).

The construction sector stands as a primary industry wherein Iron finds significant utilisation. The construction industry is an essential pillar of China's national economy (Li et al. 2020), and China’s construction industry has been expanding since 2001. The growth of China’s economy has led to a substantial expansion of urban, rural, and residential construction on a significant scale.

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The methodology includes descriptive analysis to summarise the exports and imports data, quantitative measures utilising Social Network Analysis to assess network metrics such as out-degree, in-degree, and weighted criteria, and Pearson Correlation coefficient to quantify the strength and direction of linear relationships between continuous variables. By combining descriptive and quantitative approaches, this study seeks to enhance our understanding of the international iron trade and its network dynamics.

This study is highly relevant because it focuses on the international iron trade, particularly within the Brazil-China network. Understanding the dynamics of this trade is essential, given the global significance and the increasing demands from emerging economies like China. Additionally, the study sheds light on the pivotal role of the construction sector, where iron utilisation is significant, particularly in China's booming construction industry. The study provides comprehensive insights into the network dynamics and quantifies the relationships between variables using descriptive and quantitative analysis methods. This study contributes to a deeper understanding of the international iron trade's implications and impact on the construction sector and broader economic dynamics.

2. International Iron Trade

Previous studies have analysed the International Iron Trade. In this section, the primary outcomes of these studies will be highlighted.

Trade is pivotal in enabling nations to mitigate the adverse effects of local or regional supply disruptions or shocks (Gephart et al. 2016, Tamea et al. 2016, Hao & An 2022). Iron ore, a vital and indispensable raw material, fosters economic growth and development. Consequently, importing iron ore becomes a highly competitive arena among various stakeholders. The acquisition and trade of iron ore have far-reaching implications for economic prosperity and resource allocation, making it imperative to explore the dynamics and complexities surrounding this crucial commodity (Hao et al. 2018).

Iron holds the distinction of being the most extensively utilised metal across various industries and applications. Its unparalleled prevalence stems from its exceptional properties, versatility, and natural abundance. As a highly malleable and durable metal, Iron finds widespread application in sectors such as construction, automotive, machinery, and infrastructure development. Its magnetic properties also make it indispensable in electrical and electronic equipment. Moreover, Iron's cost-effectiveness and recyclability further contribute to its status as the most widely employed metal, playing an integral role in driving economic growth and technological advancements on a global scale (Pauliuk et al. 2013, Yan & Wang 2014).

Australia is the largest iron ore producer, accounting for 40% of the global production. Brazil follows closely with a share of 21%, while India lags with a modest contribution of only 7% (Hao et al. 2018, Ericsson & Löf 2008). Australia holds significant international market power in China and Germany through its iron ore exports. Likewise, Brazilian iron ore exports possess global market influence in China, Japan, and Germany. Additionally, India's iron ore exports demonstrate global market strength, specifically in China and the Japanese market (Wan 2017).

Characterised by a remarkable array of mineral resources and many operational mines, Brazil showcases its diverse mineral wealth with over 70 ores, including 21 metallic varieties. The country's mining operations mainly consist of small open-pit mines, extracting non-metallic materials such as granite, ornamental rocks, and kaolin. Brazil holds the world's leading reserves of niobium and tantalite, ranks second in tin and graphite reserves, and stands as the fifth-largest producer of iron ore globally. This extensive mining portfolio reflects Brazil's prominence in the global mining sector, highlighting its ability to effectively harness and exploit its abundant mineral resources (Pillonel & Sutorius 2005)

As an endeavour deeply intertwined with Brazil's historical narrative, mining has exerted a profound influence across multiple dimensions, including economic, political, social, geographic, demographic, artistic, and religious realms. The intricate and enduring relationship between mining activities and Brazilian culture has left an indelible mark on numerous facets of national life, spanning centuries of intertwining histories. Acknowledging the inextricable bond between mining and the multifaceted

tapestry of Brazilian society is imperative to comprehend the intricate tapestry that has shaped the nation's identity and development over time (Machado & Figueirôa 2022).

China's domestic construction activities rely on imported resources (Chuai et al. 2021), with the imported amounts being influenced significantly by both the pull effect from the economy and the regional natural resource endowment. Notably, regions abundant in iron ore, such as Australia, Brazil, and South Africa, are among the primary sources from which China imports ores (Beukes, et al. 2003), as China has maintained its status as the foremost global importer of iron ore (Wan 2017).

In summary, previous studies have highlighted the significance of the international iron trade, emphasising its role in economic growth and resource allocation. Iron is widely utilised across various industries due to its exceptional properties, versatility, and abundance. Australia is the largest iron ore producer, followed by Brazil and India. These countries exert global market power through iron ore exports to China, Japan, and Germany. Brazil's rich mineral resources, including substantial iron ore reserves, showcase its prominence in the global mining sector. China heavily relies on imported iron ore for its construction activities. Understanding these dynamics is crucial for comprehending the complexities of the international iron trade and its implications for global development and resource management.

3. Materials and Methods

3.1. Materials

The study will rely on data from the World Integrated Trade Solution (WITS) and World Bank databases. It will gather information on Brazilian iron ore exports and the activity level in the Chinese construction sector over a specific period.

Once the data has been collected, it will be processed and analysed using a combination of Excel and Gheph. Excel will clean the data, generate statical analysis, and generate graphical visualisation. Gheph, on the other hand, will be used to create network calculations and graphic visualisations.

3.2. Methods

This study aims to generate International Iron Trade Insight and better understand the network Brazil-China. Both descriptive analysis and quantitative measures will be used to accomplish the goals.

Descriptive: The first step involves comparing exports and imports data per country to obtain an overview of the International Iron Trade. This step is focused on describing and summarising the data.

Quantitative: The second step involves analysing the data using Gephi, which likely employs quantitative measures to assess the degree level of out-degree, indegree, weighted out-degree, and weighted in-degree per country. These measures involve numerical calculations and provide quantitative information about the network.

Quantitative: The third step involves using the Pearson correlation coefficient, a statistical measure, to quantify the strength and direction of the linear relationship between two continuous variables. This step also relies on quantitative analysis.

3.3. Pearson Correlation

The Pearson correlation coefficient will be used to determine the strength of the linear relationship between the two variables, with values ranging from -1 (perfect negative correlation) to +1 (perfect positive correlation). The results of the correlation analysis will be interpreted using a significance level of 0.05 to determine whether the observed correlation is statistically significant or due to chance. (Csordás & Füzesi 2023, Várallyai et al. 2015) This study will analyse the correlation between Brazilian Iron Exports and the China Construction Industry revenue.

3.4. Social Network Analysis

Social Network Analysis is a suitable approach for examining the behaviour of products within the context of international trade (Popp et al. 2018). The degree centrality, a social network analysis metric, consists in counting the number of connections of each vertex (Grandjean 2021).

In-degree centrality concentrates on a specific individual as the point of focus; the centrality of all other individuals is based on their relation to the focal point of the “in-degree" individual (De Laat et al. 2007).

Out-degree is a measure of centrality that still focuses on a single individual, but the analytic is concerned with the out-going interactions of the individual; the extent of out-degree centrality is how many times the focus point individual interacts with others (De Laat et al. 2007, Aledavood et al. 2018, Pancsira 2022).

In this study, the vertex represents the countries, and the in-degree and out-degree centrality will be applied to understand the level of connections between them in the Iron Trade Network.

4. Results and Discussion

4.1. Degree Ratio

Figure 1 provides valuable insights into this network's ratio of indegree and out-degree per country. By examining these ratios, we can better understand the connectivity and influence of countries participating in the iron trade. The in-degree percentage signifies the extent to which a country receives connections from other countries, reflecting its popularity or prominence. Conversely, the out-degree ratio indicates the level of relations initiated by a country, indicating its activity and influence within the network. This chart will shed light on the dynamics and relationships between countries involved in the international iron trade, offering valuable insights for further analysis and decision-making.

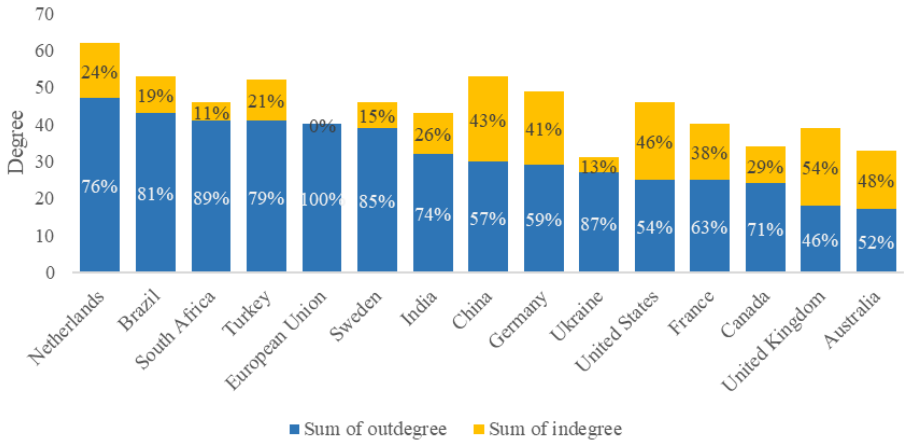

Figure 1. TOP Countries by Degree

Source: Authors’ own editing, 2023

Figure 1 displays the out-degree and indegree ratio per country in the International Iron Trade network context. Despite not being a significant exporter of Iron, the Netherlands stands out with the highest out-degree ratio of 47. This factor can be attributed to the Rotterdam effect, as the Port of Rotterdam plays a crucial role in facilitating trade connections and acting as a prominent transportation hub. The port’s strategic location and efficient infrastructure enable the Netherlands to actively initiate relationships with other countries involved in the iron trade, despite its lower iron export volume. This factor emphasises the significance of considering the Rotterdam effect when analysing the connectivity and trade dynamics of countries within the International Iron Trade network.

On the other hand, Australia, a significant exporter of Iron, has a lower out-degree ratio of 17 compared to Brazil's out-degree ratio of 43. This number might seem counterintuitive, considering

Australia's higher export volume. However, the out-degree ratio considers the export volume and the number of connections initiated. It implies that Brazil establishes more relationships with other countries despite exporting less Iron than Australia, thus exhibiting a higher out-degree ratio.

Other notable findings include China, which has a high in-degree ratio of 23, indicating that it receives significant connections from various countries involved in the iron trade. It highlights China's prominence and popularity as a destination for iron imports. Similarly, the United States, Germany, and the United Kingdom also have relatively high indegree ratios, signifying their significance as destinations for iron exports.

Overall, the chart reveals intriguing insights into the connectivity and influence of countries within the International Iron Trade network. It underscores the importance of considering the export volume and the number and nature of connections established when assessing a country's role in the iron trade.

4.2. International Iron Trade

International iron trade involves the exchange of iron and iron-related products between countries, including importing and exporting iron ore, steel, and other iron-based commodities. Iron ore is sourced from countries with abundant deposits and exported to nations with steel industries.

Geph was used to visualise the leading importers and exporters of Iron. Data related to Iron (Product code: 2601 - Iron ores and concentrates, including roasted iron pyrites - HS 1996) from 2022 was gathered in the WITS database. Figure 2 shows the top 10 countries by the weighted out-degree sum, representing the network's leading exporters.

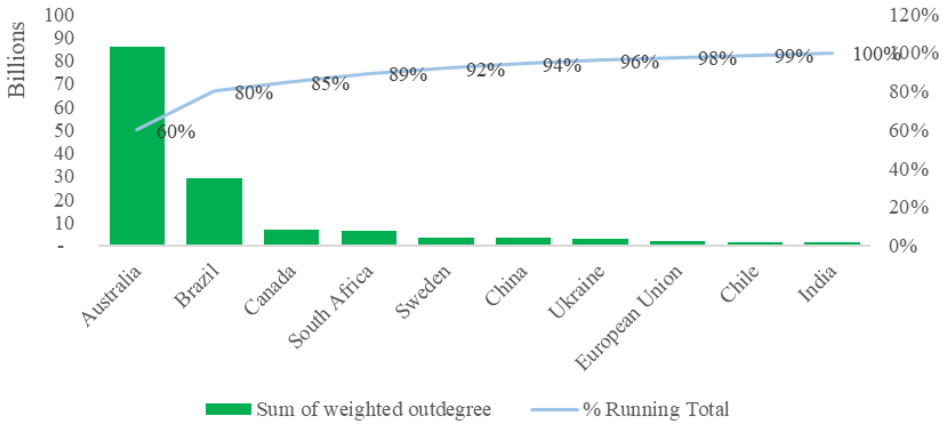

Figure 2. TOP 10 Countries by the Sum of Weighted Out-degree

Source: Authors' own editing, 2023

Australia is the leading exporter of Iron, as its share represents 60% of the total value of exports. Brazil is the second largest in exports, representing 20%. Australia's favourable geological conditions, infrastructure investments, stable political environment, diversified market access, and mining expertise have contributed to its dominant position in the global iron ore market.

Figure 3 shows the visualisation generated in Geph. The circle sizes represent the weighted in-degree per country. It is possible to see that Australia and Brazil are the leading exporters in the network. The colour strength means the commercial partners.

It is possible to see that, despite Australia's exporters more in value than Brazil, Brazil, on the other hand, has more commercial partners. The arrow shows the flows from exporters to importers. It is possible to see that the primary importer is China.

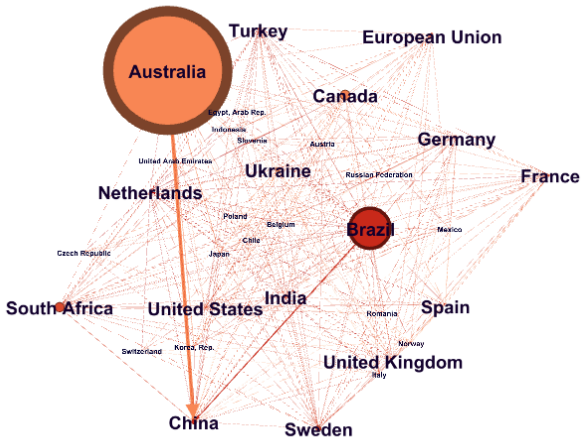

Figure 3. Out-degree Network

Source: Authors' own editing, 2023

Figure 4 presents the top 10 countries based on the sum of their weighted indegree, showcasing their status as crucial importers in the network. The figure also displays the percentage of the total weighted indegree, providing insights into the relative importance of each country's import activity.

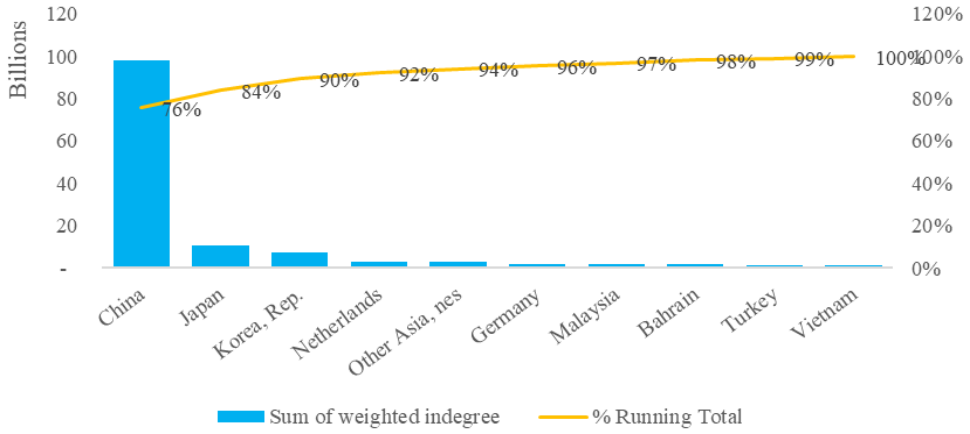

Figure 4. TOP 10 Countries by the Sum of Weighted Indegree

Source: Authors' own editing, 2023

China is a significant importer of Iron, representing 76% of global iron imports. It is due to China's rapid industrialisation and urbanisation, which has driven high demand for iron ore to support construction and infrastructure development. China's steel production capacity exceeds its domestic iron ore production, leading to a heavy reliance on imports. The country has established strong trade relationships with significant exporters like Australia and Brazil. Australia is the leading exporter due to its abundant high-grade iron ore reserves, efficient infrastructure, stable political environment, and diversified market access. Brazil is the second-largest exporter, facing challenges related to infrastructure and lower-grade iron ore reserves.

Figure 5 depicts a visualisation generated in Geph, where circle sizes correspond to the weighted degree per country. The colour intensity, on the other hand, signifies the commercial partners.

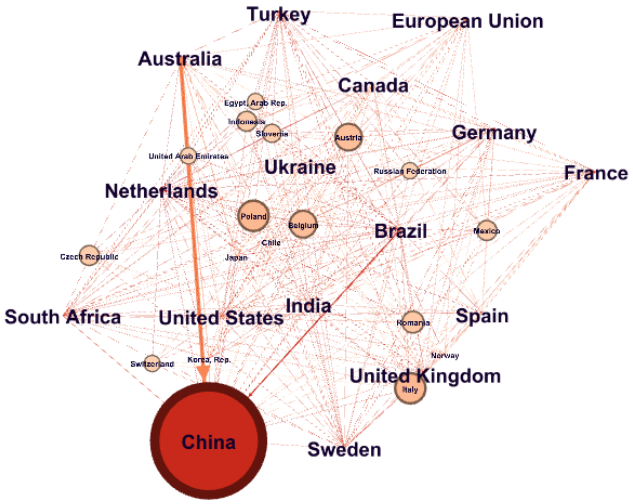

Figure 5. Indegree Network

Source: Authors' own editing, 2023

Notably, China emerges as the dominant importer, evident from its apparent circle size and rich red hue, indicative of its extensive network of commercial connections compared to other countries.

4.3. Brazil's International Iron Trade

Figure 6 comprehensively depicts Brazil's iron exports to the global market from 1996 to 2022. This time series analysis allows for examining the patterns and trends in Brazil's iron export volumes over a significant timeframe.

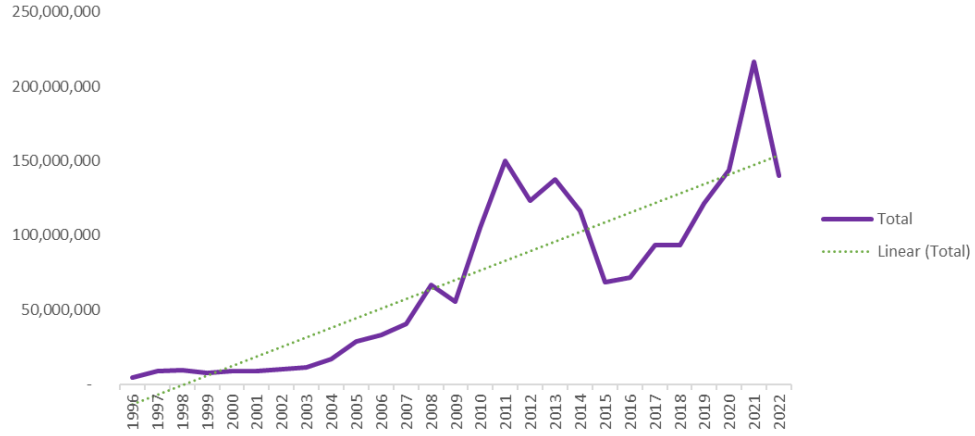

Figure 6. Brazilian Iron Exportation to World Over Time

Source: Authors' own editing, 2023

The Brazilian iron ore trade experienced a growth trend from 1996 to 2011, with some fluctuations. In 2009, there was a decline in the business due to the global financial crisis. However, the trade experienced a growth peak from 2009 to 2011 due to increased demand from China and other emerging economies. 2012 the business declined due to a drop in global demand and oversupply issues. In 2013, there was another peak in trade due to increased demand from China, but from 2013 to 2015, there was a considerable decrease in business due to oversupply issues and declining demand. From 2015 to 2021, trade saw a massive increase due to a recovery in the global market, particularly from China. However, there was a decline in business in 2022, and some possible reasons for this include a slowdown in the

global economy, supply chain disruptions caused by the COVID-19 pandemic, environmental and regulatory factors, and fluctuations in iron ore prices.

4.4. Construction Sector in China

Following the advent of the new millennium, the construction industry has emerged as a prominent sector in China, positioned as the fourth pillar industry after industry, agriculture, and commerce (Liu et al. 2013). Therefore, the construction industry is an essential pillar of China's national economy (Li et al. 2020), and China's construction industry has been expanding since 2001. The growth of China's economy has led to a substantial expansion of urban, rural, and residential construction on a significant scale. This expansion has positioned the construction industry as a crucial pillar of the national economy, playing a vital role in economic and social development. Moreover, the construction industry occupies a considerable share of the national economy, underscoring its significance in driving economic and societal progress (Tang et al. 2012).

China's domestic construction activities rely on imported resources (Chuai et al. 2021), with the imported amounts being influenced significantly by both the pull effect from the economy and the regional natural resource endowment. Notably, regions abundant in iron ore, such as Australia, Brazil, and South Africa, are among the primary sources from which China imports ores (Beukes et al. 2003), as China has maintained its status as the foremost global importer of iron ore (Wan 2017).

Figure 7 presents a time series of the Chinese construction sector's GDP from 1998 to 2020. It visually represents the sector's contribution to China's overall economic output. Analysing the chart can provide insights into the construction industry's growth, fluctuations, and trends, highlighting its evolving significance in the Chinese economy during the specified period.

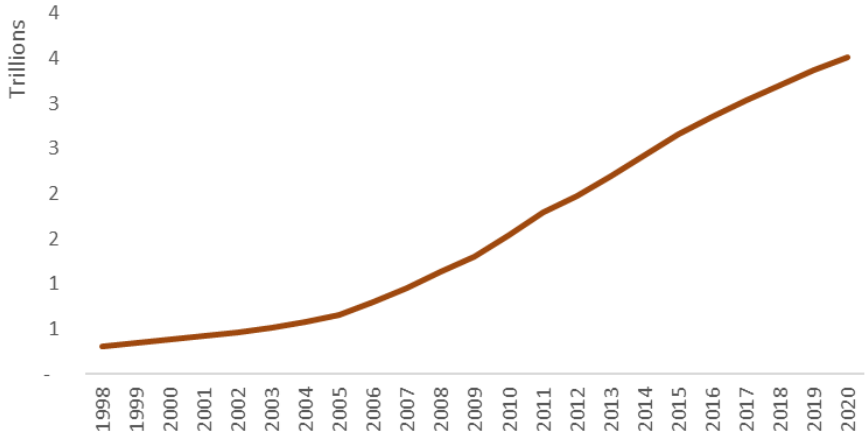

Figure 7. Chinese Construction Sector GDP Over Time

Source: Authors' own editing, 2023

The growth of the Chinese industrial sector since 1998 can be attributed to several factors, including China's economic reform program, which led to significant changes in the country's economic structure, a large and rapidly expanding domestic market, a solid manufacturing base, government policies supporting industry sector development, and investment in infrastructure and technological innovation.

4.5. Correlation Analysis between Brazil's Iron Ore Exports and Constructions Industry in China

Table 1 reveals significant correlations between Brazil's Iron Exports, Brazilian GDP, Chinese construction sector GDP, and world construction sector GDP, indicating strong positive relationships. These correlations suggest that Brazil's iron exports are closely tied to the performance of the construction sectors in both China and the global economy. At the same time, Brazil's GDP demonstrates a strong association with both the Chinese construction sector and the world construction sector. These findings emphasise the interconnectedness of Brazil's iron exports, economic performance, and the

global construction industry, highlighting the need for further investigation into the underlying factors driving these correlations.

Table 1. Pearson correlations

	The sum of Brazil Iron Exports in *1000 USD*	Brazil GDP	Chinese Construction Sector GDP *USD*	World Construction Sector GDP *USD*
The sum of Brazil Exports in 1000 USD	1.00			
Brazil GDP	**0.86**	1.00		
Chinese Construction Sector GDP (current USD)	**0.66**	**0.89**	1.00	
World Construction Sector GDP (current USD)	**0.72**	**0.93**	**0.99**	1.00

Source: Authors' own editing, 2023

Table 1 presents several Pearson correlation coefficients involving Brazil's Iron Exports, Brazilian GDP, Chinese construction sector GDP, and world construction sector GDP. Each correlation coefficient quantifies the strength and direction of the linear relationship between the respective variables.

The correlation coefficient of 0.66 between Brazil's Iron Exports and the Chinese construction sector GDP indicates a moderately strong positive correlation. It suggests that changes in Brazil's iron exports are associated with fluctuations in the Chinese construction sector's GDP. The demand for iron ore in China's construction industry, driven by infrastructure projects and construction activities, likely contributes to this relationship.

The correlation coefficient of 0.72 between Brazil's Iron Exports and the world construction sector GDP indicates a strong positive correlation. This suggests that changes in Brazil's iron exports are associated with fluctuations in the global construction sector's GDP. The world construction sector relies on iron ore for infrastructure and building projects, and as demand for construction materials rises worldwide, Brazil's iron exports increase to meet this demand.

The correlation coefficient of 0.86 between Brazil's Iron Exports and GDP indicates a strong positive correlation. This suggests that changes in Brazil's iron exports are closely associated with fluctuations in the country's overall economic performance. Iron exports play a significant role in Brazil's economy, and changes in this sector can impact the country's GDP.

The correlation coefficient of 0.89 between the Brazilian GDP and the Chinese construction sector GDP indicates a strong positive correlation. This suggests that changes in Brazil's overall economic performance are closely related to fluctuations in the Chinese construction sector's GDP. Economic conditions, government policies, and investment patterns in Brazil and China can contribute to this strong correlation.

Lastly, the correlation coefficient 0.93 between the Brazilian GDP and the world construction sector GDP indicates a robust positive correlation. This suggests that changes in Brazil's overall economic performance are strongly associated with fluctuations in the global construction sector GDP. Brazil's economic activity, including sectors beyond iron exports, can influence and be influenced by global construction trends and investment patterns.

It is important to note that correlation coefficients provide statistical summaries of the relationships between variables but do not establish causation. Further research, analysis, and consideration of other factors are necessary to understand better the underlying causal mechanisms and complexities involved in these correlations.

5. Conclusion

Australia and Brazil stand out as the leading exporters in the global iron ore market. Australia is dominant, accounting for 60% of total iron ore exports, attributed to favourable geological conditions, infrastructure investments, political stability, diversified market access, and mining expertise. Brazil follows as the second-largest exporter, representing 20% of global exports. Despite Australia exporting more in terms of value, Brazil has a more significant number of commercial partners.

The network analysis conducted using Geph provides further insights into the iron ore trade dynamics. The visualisation highlights China as the prominent importer, responsible for 76% of global iron imports. China's robust industrialisation and urbanisation processes drive its high demand for iron ore, primarily for construction and infrastructure development. With limited domestic iron ore production, China heavily relies on imports, establishing strong trade relationships with critical exporters like Australia and Brazil.

By employing Geph, it becomes evident that China is prominent in the network analysis. Its significant circle size and intense red hue demonstrate extensive commercial connections compared to other countries. It reinforces China's dominant role as the primary importer in the iron ore market, emphasising its reliance on major exporting countries such as Australia and Brazil.

The analysis of the correlation coefficients presented in this study, which highlights the relationships between Brazil's Iron Exports, Brazilian GDP, Chinese construction sector GDP, and world construction sector GDP, provides valuable insights into the interdependencies and interactions within the global economy. The correlations reveal strong positive associations, indicating the significant interdependence of these variables. It further reinforces the prominence of Australia and Brazil as the leading exporters in the global iron ore market, with Australia holding the dominant position and Brazil following as the second-largest exporter. The correlations also shed light on the importance of China as the major importer responsible for a significant portion of global iron imports. It underscores China's robust industrialisation and urbanisation processes, driving its high demand for iron ore. Therefore, studying correlations and understanding these dynamics is crucial for policymakers, economists, and industry stakeholders to make informed decisions and navigate the complexities of the global economic landscape, particularly in the context of the iron ore trade.

Studying correlations between variables, as showcased in this study, is crucial for understanding the interdependencies and interactions within the economy. It allows us to identify the relationships between indicators, such as Brazil's Iron Exports, GDP, and construction sector performance, providing insights for decision-making and strategy formulation. Additionally, it helps us comprehend global market dynamics, revealing linkages between countries, industries, and sectors. By studying correlations, we can identify leading indicators, anticipate future economic trends, and uncover underlying causal factors, contributing to advancing economic theory and enabling better forecasting and decision-making in an increasingly interconnected world.

In conclusion, the analysis of the correlation coefficients presented in the table provides valuable insights into the relationships between Brazil's Iron Exports, Brazilian GDP, Chinese construction sector GDP, and world construction sector GDP. The correlations reveal strong positive associations, indicating the interdependence of these variables within the global economic context. The findings highlight the significance of Brazil's iron exports concerning the construction sectors in China and worldwide, as well as the close ties between Brazil's overall economic performance and the global construction industry. These correlations underscore the need for further research to explore the underlying mechanisms and factors that drive these relationships. Understanding these dynamics is essential for policymakers, economists, and industry stakeholders to make informed decisions and navigate the complexities of the global economic landscape.

References

Aledavood, T., Lehmann, S. & Saramäki, J. 2018, 'Social network differences of chronotypes identified from mobile phone data', *EPJ Data Science*, Vol. 7, No. 46.

Beukes, N.J., Gutzmer, J. & Mukhopadhyay, J. 2003, 'The geology and genesis of high-grade hematite iron ore deposits, *Applied Earth Science*, Vol. 112, No. 1, pp. 18-25.

Carina Roberta, D., de Souza Leite, G. & Mori, J.S. 2016, 'Evolução das relações comerciais entre Brasil e China: Uma análise dos anos 2002 a 2014'*, Revista ESPACIOS| Vol.37 (Nº 24)*

Chuai, X., Lu, Q., Huang, X., Gao, R. & Zhao, R. 2021, 'China's construction industry-linked economy-resources-environment flow in international trade', *Journal of Cleaner Production*, Vol. 278, p. 11, doi:10.1016/j.jclepro.2020.123990

Csordás, A., & Füzesi, I. 2023. 'The impact of technophobia on vertical farms', *Sustainability*, 15(9) doi:10.3390/su15097476

De Laat, M., Lally, V., Lipponen, L. and Simons, R. (2007), "Investigating patterns of interaction in networked learning and computer-supported collaborative learning: A role for Social Network Analysis", *International Journal of Computer-Supported Collaborative Learning*, Vol. 2, pp. 87-103.

De Oliveira, H.F. & Lengyel, P. 2021, 'Taxation Impacts on Brazilian Trade' , *Journal of EcoAgriTourism*, Vol. 17, No. 2.

Ericsson, M. & Löf, A. 2008, 'Iron Ore: Measuring the Market', *Engineering and Mining Journal*, Vol. 209, No. 7, pp. 74.

Gephart, J.A., Rovenskaya, E., Dieckmann, U., Pace, M.L. & Brännström, Å 2016, 'Vulnerability to shocks in the global seafood trade network', *Environmental Research Letters*, Vol. 11, No. 3, doi:10.1088/1748-9326/11/3/035008

Grandjean, M. 2021, 'Introduction to Social Network Analysis: Basics and Historical Specificities', *HNR ResHist Conference 2021*.

Hao, X. & An, H. 2022, 'Comparative study on the transmission mechanism of supply shortage risk in the international trade of iron ore, pig iron and crude steel', *Resources Policy*, Vol. 79, doi: 10.1016/j.resourpol.2022.103022

Hao, X., An, H., Sun, X. & Zhong, W. 2018, "The import competition relationship and intensity in the international iron ore trade: From network perspective", *Resources Policy*, Vol. 57, pp. 45-54.

Kesler, S.E. & Laznicka, P. 1994, 'Mineral Resources, Economics, and the Environment', *Ore Geology Reviews*, Vol. 9, No. 6, pp. 511-512.

Li, B., Han, S., Wang, Y., Li, J. & Wang, Y. 2020, 'Feasibility assessment of the carbon emissions peak in China's construction industry: factor decomposition and peak forecast', *Science of the Total Environment*, Vol. 706, pp. 135716.

Liu, B., Wang, X., Chen, Y. & Shen, Y. 2013, 'Market structure of China's construction industry based on the Panzar–Rosse model', *Construction Management and Economics*, Vol. 31, No. 7, pp. 731-745.

Machado, I.F. & Figueirôa, S. 2022, 'Mining history of Brazil: a summary', *Mineral Economics*, Vol. 35, No. 2, pp. 253-265.

Ministério da Economia 2021, *Exportação e Importação Geral*. Available: http://comexstat.mdic.gov.br/pt/geral.

Nassif, A. & Castilho, M.R. 2020, 'Trade patterns in a globalised world: Brazil as a case of regressive specialisation', *Cambridge Journal of Economics*, Vol. 44, No. 3, pp. 671-701.

Nassif, A., Morandi, L., Araújo, E. & Feijó, C. 2020, 'Economic development and stagnation in Brazil (1950–2011)', *Structural Change and Economic Dynamics*, Vol. 53, pp. 1-15.

Pancsira, J. 2022, 'International Coffee Trade: a literature review', *Journal of Agricultural Informatics* 13:1 p. 26, doi:10.17700/jai.2022.13.1.654

Pauliuk, S., Milford, R.L., Müller, D.B. & Allwood, J.M. 2013, 'The steel scrap age', *Environmental science & technology*, Vol. 47, No. 7, pp. 3448-3454.

Pillonel, B. & Sutorius, N. 2005, 'Brazil Mining: An Industry On The Rise', *Engineering and Mining Journal*, Vol. 206, No. 1, pp. 26.

Popp, J., Kiss, A., Oláh, J., Máté, D., Bai, A. & Lakner, Z. 2018, 'Network analysis for the improvement of food safety in the international honey trade', *Amfiteatru Economic*, Vol. 20, No. 47, pp. 84-98.

Qiangfeng, L., Weiqiong, Z., Gaoshang, W., Jinhua, C., Tao, D., Bojie, W., Liang, L. & Qindong, Y. 2018, 'Material and value flows of iron in Chinese international trade from 2010 to 2016', *Resources Policy*, Vol. 59, pp. 139-147.

Tamea, S., Laio, F. & Ridolfi, L. 2016, 'Global effects of local food-production crises: a virtual water perspective', *Scientific reports*, Vol. 6, No. 1, pp. 18803.

Tang, J.J., Liang, W.Z., Hu, S.H. & Zhao, T.S. 2012, 'Present situation analysis and development trend forecast of China's construction industry', *Applied Mechanics and Materials*, Vol. 121, pp. 4053-4058.

Várallyai, L., Herdon, M., Botos, Sz. 2015, 'Statistical Analyses of Digital Divide Factors', *Procedia Economics and Finance*, Vol 19, pp. 364-372, doi:10.1016/S2212-5671(15)00037-4.

Wan, X. 2017, 'An analysis of measuring market power in the international iron ore trade', *Journal of Interdisciplinary Mathematics*, Vol. 20, No. 3, pp. 749-759.

Wang, C.C. 2011, 'An Empirical Analysis of International Trade Network of Iron Ore', *Applied Mechanics and Materials*, Trans Tech Publ, pp. 887.

Yan, L. & Wang, A. 2014, 'Based on material flow analysis: Value chain analysis of China iron resources', *Resources, Conservation and Recycling*, Vol. 91, pp. 52-61.