



Infrastructure Interpretation of the Most Prominent Countries in the World's Medical Device Trade

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Abstract

The international medical device trade has received a lot of attention since the coronavirus disease 2019 (COVID-19) pandemic. To maintain domestic supply of medical devices, some countries have sought multilateral trade cooperation or simply implemented export restrictions, exacerbating the global medical device market's instability and fragility [1-15]. Government policymakers must identify the most influential countries in the international medical device trade and prevent exports. However, due to the complexities of the international medical device trade, few efforts have been made in previous studies to investigate various countries' influence on the international medical device trade relationships. This study builds a global medical device trade network (GMDTN) and investigates the criticality of various countries from a network-based perspective to fill these research gaps. The GMDTN's evolution patterns and geographical distribution of influence are revealed. Details on how the influence of some key countries has developed are provided. According to the findings, the global medical device trade market is export oriented. Some countries' strong influence may be formed as a result of their large number of trading partners or the deep reliance of some of those trading partners on that country (namely, breadth- or depth-based patterns). It is worth noting that the United States holds a commanding position in the international medical device trade as well as depth. Furthermore, some countries, despite not being critical direct trading partners, play an important role as intermediaries in the formation of other countries' influence. The study's findings have implications for policymakers seeking to understand countries' influence on the international medical device trade and to proactively plan responses to unexpected changes in this trade.

Introduction

The ongoing global coronavirus disease 2019 (COVID-19) pandemic has triggered an unprecedented global health crisis, emphasising the importance of the international medical device trade, which has grown steadily over the last three decades, with most countries relying on imports. Global demand for medical devices is rising as the world's population ages and life expectancy rises. As a result, medical devices are an essential component of patient care.

However, as a result of global trade frictions, aggressive unilateral nationalism, and trade protectionism the international trading environment has become increasingly complicated. These factors have heightened the importance of stable global trading systems and trade cooperation to unprecedented levels. To deal with COVID-19, 54 governments recently imposed export restrictions and trade barriers on medical supplies and medicines [6], increasing the uncertainty in the international medical device trade. As a result, in order to maintain domestic healthcare systems and the vital medical supply trade, flow, government policymakers must understand the complex global medical device trade system. It is critical for them to quantify countries' influence in the international medical device trade, identify highly influential countries and their geographical spheres of influence, analyse variation in such influence, and investigate the key factors involved in influence formation. Complex network theory has previously been used to analyse global trade structure and evolution patterns. Previous studies on the influence of countries on global trade have primarily used a static analysis perspective quantifying countries' influence using traditional indicators such as degree and strength, as well as other centrality indices. Previous studies, however, had two limitations. First, because medical devices are critical commodities, structural analyses of the global medical device trade network (GMDTN) are uncommon. Second, previous studies' static indicators, used as part of a simple evaluation method, ignored some critical information about countries' influence, such as the dynamic patterns of such influence, as well as

the detailed propagation paths in real-world scenarios. Furthermore, static indicators cannot reflect the impact scope and transmission paths of export restrictions in some countries. Analyzing countries' dynamic influence in the international medical device trade helps us understand how influence forms in different scenarios, such as when production declines due to COVID-19, trade traffic accidents occur, or new export restriction policies are issued.

To address these research gaps, this study examines the structural evolution of the global medical device trade from 1990 to 2020 and investigates the influence of various countries on the international medical device trade from both static and dynamic perspectives using complex network theory. This study makes two major contributions. First, the structural evolution of the international medical device trade is examined from a network-based standpoint, addressing a limitation of previous studies on the systematic review of the global medical device trade. Second, influential countries are identified both statically and dynamically. New export restriction policies, in particular, are issued. Instead of traditional static indicators, a linear threshold (LT) model is used to examine countries' dynamic influence in a realistic scenario, namely, government-mandated export reduction. Certain critical countries' geographical spheres of influence, detailed

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Received: 04-Aug-2022, Manuscript No: ijaiti-22-71428, **Editor assigned:** 06-Aug-2022, PreQC No: ijaiti-22-71428 (PQ), **Reviewed:** 20-Aug-2022, QC No: ijaiti-22-71428, **Revised:** 22-Aug-2022, Manuscript No: ijaiti-22-71428 (R), **Published:** 29-Aug-2022, DOI: 10.4172/2277-1891.1000182

Citation: Hu X (2022) Infrastructure Interpretation of the Most Prominent Countries in the World's Medical Device Trade. Int J Adv Innovat Thoughts Ideas, 11: 182.

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propagation paths, and influence formation patterns are revealed. The sophisticated quantitative findings assist policymakers in developing effective policies to ensure the safety of the medical device trade.

Subjective Heading

Competitiveness, trade promotion, and forecasting for the medical device trade are well-studied research topics. The COVID-19 pandemic has recently drawn a lot of attention to the medical device industry. Because of the high demand for medical devices, some countries have implemented export restrictions to ensure that domestic needs are met, and some countries have even increased their imports due to severe domestic shortages. Export restrictions have inevitably heightened trade tensions in today's global trading system. Evenett discussed relevant trade policies on COVID-19-related commodities in this context and discovered that prepandemic barriers to global medical trade supplies remained. The preceding study also examined restriction policies such as export controls and import taxes. Similarly, Bown focused on restrictive policies regarding hospital equipment, pharmaceuticals and food adopted by the EU, the US and China.

Discussion

Many previous studies have found that restrictive export policies and reduced medical device production capacity have negative effects on areas such as public health and trade power. According to Evenett and Winters the fragmented production patterns caused by export restrictions are extremely costly in some countries. Furthermore, medical device export restrictions have not encouraged much-needed domestic production expansion. Furthermore, investigated the negative effects of reduced medical device supply on public physical health as well as mental health. The effects of COVID-19 on trade strength and country vulnerability were assessed using data from the global medical device trade and the trade of other specific commodities. Chugaiev discovered that 90 percent of the world's largest 100 economies are completely vulnerable to trade. Exporters of medical products and information and communications technology (ICT) services, on the other hand, are found to have relatively better trade soundness. In addition to considering global impacts, some analyses have concentrated on specific regions. Leibovici and Santacreu emphasised the United States' heavy reliance on imports of essential medical commodities, revealing that this reliance is a significant contributor to the recent increase in the US trade deficit. In recent times, According to research, the negative consequences of limited medical supplies on African or developing countries have been investigated. Many scholars have investigated potential response strategies for such trade disruptions in the face of the negative impact of COVID-19 shocks on global trade of medical goods. Global cooperation mechanisms, for example, have been proposed to ramp up production and ensure the supply of medical goods.

In recent years, complex network theory has been increasingly used in trade-related studies. When constructing a trade network, countries and trade relationships are treated as nodes and edges, respectively. Different approaches are used to define the weights and directions of edges in trade networks. Complex network theory, in contrast to other methods, emphasises intricate trade relationships, rather than just direct trade relationships between countries in the trade network.

Previous research based on complex network theory has primarily focused on the structural characteristics and evolution patterns of the trade network from a variety of perspectives, such as detecting trade communities formed by some countries with close trade relationships. analysing the structure of the core and periphery evaluating the

centrality of countries and identifying the relationships between the centrality of countries and other country characteristics formation investigating changes in structural characteristics during evolution investigating risk transmission in the trade network and determining trade network robustness

Notably, the centrality of countries in the trade network is an important issue to investigate in the trade network, which has implications for the trade network's emphasis and the influence of countries in this network. In previous studies, node centrality indicators were used. degree and fortitude Node degree in the trade network reflects the number of trade channels in a country, while node strength measures trade flows in a country. More measures, such as eigenvector centrality between centrality and the PageRank algorithm .have been proposed to identify the centrality of nodes in the network as complex network theory has advanced. These indicators are widely used to assess the importance of countries in trade networks. For example, De Andrade and Rêgo used centrality indicators to identify the most influential countries in a trade network, revealing that the countries with the tightest connections, highest cash flow, or highest trade volume were the most influential. The most influential were those with intermediary status in the trade network. Furthermore, Wang and Li [36] revealed the geographical movement pattern of the centrality of China's interregional coal trade network from 1997 to 2016. According to the centrality of countries in the crude oil trade network has a significant impact on their GDP (GDP). Vidya and Prabheesh investigated changes in country centrality as a result of COVID-19-related disruptions and discovered that China's central position in the global trade network remains stable. Furthermore, the centrality of countries in the global trade network has been found to be related to infections and deaths because of the COVID-19 pandemic. The preceding studies not only examined the global trade network as a whole but also the trade networks of specific commodities such as energy.

According to the review of the relevant literature mentioned above, there are two research gaps. First, as stated in Section, previous studies have rarely reported on research activities involving the GMDTN. Although many previous studies have found that export restrictions and reduced medical device production capacity have negative effects in some areas, overall structural analyses of the GMDTN have rarely been discussed. Second, the countries with the most clout in the international trade network for other commodities have been identified primarily using static indicators. The Dynamic propagation and influence formation patterns (width/depth) have not been thoroughly investigated. However, it is critical for policymakers to have a thorough understanding of which countries are considered influential in order to implement effective trade policies.

The two research gaps mentioned above motivated this study. As a result, building on the preceding discussion, the first contribution of this paper investigates the structural evolution of the global medical device trade from 1990 to 2020. As a second contribution, this study investigates the impact of countries on international medical device trade from both static and dynamic perspectives. The dynamic influence of countries is measured in particular using a realistic scenario: supply constraints. The geographical sphere and development patterns of countries' centrality/influence in the global medical device trade are revealed. Furthermore, the propagation paths of some critical countries are investigated in the dynamic influence analysis.

The UN Comtrade database is used to obtain data on global medical device trade from 1990 to 2020. The Harmonized System (HS) codes

of commodities discussed in this study, in particular, are and medical device data are presented in Table A1. Each trade record details the movement of goods from exporting to importing countries. The trade value of commodities is the unit of trade (dollars). Because of differences in the statistical methods used in different countries, there have been some issues with different reporting countries providing inconsistent data. There are records. To address these issues, the records' outliers are filtered, and the average value of trade flow reported by different countries is calculated to represent the trade value from exporting to importing countries in this study. Appendix A1 describes the specific data processing method.

In this study, a complex network is used to understand international medical device trade among countries from a network-based perspective. This strategy option provides an in-depth analysis tool for examining the intricate trade relationships between countries and assessing the impact of individual countries on the overall trade system. As a result, annual trade networks are built using international medical device trade records from 1990 to 2020. The analysis specifically examines whether, in year t , if trade flows exist from countries I to j , then trade network G_t has an edge from nodes I to j , as shown by $e_{i,j,t}$. If an edge exists in network G_t between nodes I and j , the indicative index $a_{i,j,t}$ is set. Otherwise it is used calculated by the sum of the trade value of all medical devices. The sets of nodes and edges in G_t are shown by V_t and E_t , respectively, denoting all countries and relationships involved in the international medical device trade.

There are numerous fundamental indicators that can be used to describe the characteristics of each country in the trade network. In particular, in-degree $kit(in)$, out-degree $kit(out)$, and degree kit show country i 's imports, exports, and total trade, which are defined as out-strength, in-strength, and strength, respectively, as the simplest indicators for measuring a country's influence in the GMDTN. Net exports and imports are calculated using out-strength and in-strength, respectively, to determine a country's role in global trade. Appendix A2 contains detailed calculations for the aforementioned indicators.

Furthermore, there are some significant indicators that can be used to assess the structural features of the entire network. In particular, in-degree centrality $ct(in)$ reflects import channel competition, whereas out-degree centrality $ct(out)$ reflects export channel monopoly in the GMDTN. A high in- and out-degree centrality value indicates increased competition in import channels and a severe monopoly in export channels, respectively.

Conclusion

This study analyzes the dynamic influence of countries with assumptions in terms of country antirisk capacity. Future works can further investigate the self-adaptive behaviors of countries under the influence of their trading partners and thus provide a more realistic assessment of countries' dynamic influence. Furthermore, this study focuses on the export restrictions of countries to analyze the process

of influence formation. In future works, the probability of export restrictions being implemented should be considered from economic, political and cultural perspectives to provide a comprehensive evaluation of countries' dynamic influence on the international medical device trade.

Acknowledgement

I would like to thank my Professor for his support and encouragement.

Conflict of Interest

The authors declare that they are no conflict of interest.

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