# Sustainable Timber Trade: A Study on Data Discrepancies and Risk of Illegality in International Trade Relationships

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## Abstract

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Illegally sourced and traded timber is often linked to social, economic, ecological, and climate issues globally. Forests act as invaluable carbon sinks amid worsening climate change and illegal timber entering markets undercut legitimate harvesters causing them economic losses. Illegal timber trade persists because of the difficulty in detection, but trade discrepancy analysis, the comparison of reported imports and exports in bilateral trade, is a useful detection method. Discrepancy can be caused by errors and is expected, but repeated patterns or excessively large discrepancies can be indicative of illegal activities like tax evasion or trade of protected species. The goals for this research are to develop a tool that uses trade discrepancy to detect potential illegal timber, compare results to other research to test the tool's reliability, and analyze trade flows identified as high risk. Trade discrepancy and global market share based on data compiled from various custom data sources to assess the risk of illegal trade for bilateral trade flows of logs, lumber, or plywood between the years of 1991 and 2020 and visualized on a global map

format using R Shiny. Map results generally complemented existing research, while case studies of trade flows evaluated as being highest risk revealed several potential causes. The two highest risk trade flows for logs, Hong Kong to China and New Zealand to Hong Kong, were found to be linked by a triangular trade pattern prone to misreporting of the trade partner that was not associated with illegal trade. Trade of logs and lumber from Ghana to India was linked with illegal trade, as Ghanaian exporters of logs were likely to misreport to avoid log export restrictions and Indian importers were likely to misreport timber products as logs to take advantage of India's low log tariffs. Indonesian reported plywood exports were higher than the imports reported by China, while the imports of logs reported by China were higher than exports reported by Indonesia. This pattern suggests product type misreporting to conceal illegal trade but the method of reporting logs as plywood is uncertain.

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# Chapter 1. Introduction

Forests are vital for maintaining biodiversity and mitigating climate change. Forests harbor most of Earth's terrestrial biodiversity, containing 60,000 tree species, 80% of amphibian species, 75% of bird species, and 68% of mammal species (WCMC, 2020). They mitigate climate change by storing carbon, absorbing a net 7.6 billion metric tons of carbon dioxide annually, about 1.5 times the amount emitted by the United States each year (Harris and Gibbs, 2021). While about 30% of total land area is forested (WCMC, 2020) nearly 40% of land area is covered by agriculture land (World Wildlife Fund, 2018). Agriculture is the most prominent force driving deforestation as growing populations require more food and lead to further expansions of agricultural land. This is especially true in tropical regions where developing nations are not only pressured to keep up with their own growth but are also trying to meet the consumer demands of wealthy, further-developed nations, including the demand for wood products. Therefore, prevention of deforestation and protection of the biodiversity of forests needs to be a global effort and not only the concern of the people in the areas where it is occurring.

The international trade of wood products needs to be monitored in way that most effectively prevents illegal wood trade. Illegal wood trade in this case includes wood derived from protected species or from a protected area, and wood that is economically illegal such as avoiding import taxes or other controls, as they undermine the profits of legitimate wood products by undercutting those products when they enter the market. This thesis attempts to use trade discrepancy analysis in a way that allows researchers and decision makers to find illegal trade and improve international efforts to prevent deforestation and biodiversity loss while promoting sustainable forest products and the mitigation of climate change.

Trade discrepancy in a bilateral trade relationship is the difference between the quantity shipped as reported by the exporter and the quantity received as reported by the importer within a given time frame. These quantities can be measures of either the volume or the value of a given product. Analysis of trade discrepancy in the forest products market helps to improve the understanding of a country's forest sector, allowing for informed decisions in policymaking, preventing losses of income and degradation of natural resources within that sector (Blundell & Mascia, 2005). This thesis attempts to use trade discrepancy analysis to 1) develop a tool that expands on previous research using trade discrepancy analysis to detect illegal timber, 2) use the tool and compare the results to previous discrepancy analysis research to test for the tool's reliability, and 3) analyze combinations of bilateral trade flows and certain wood products that are identified by the tool as being especially high risk.

Chapter 1 introduces this research and presents the context for its necessity. Chapter 2 details trade discrepancy analysis and the different factors that need to be considered while using it. Chapter 3 gives thorough examples of how it has been used previously to find sources of illegal timber. Chapter 4 provides a data overview, including data source and collection methods. Chapter 5 details the calculation methods, data manipulation, analysis, and its visualization. Chapter 6 includes comparisons of generated maps to the results of existing research on the same trade flows. Chapter 7 discusses case study analysis of the trade flows identified by the tool as being the highest risk bilateral trade flow for each product. Chapter 8 is the conclusion, with an overall assessment of the findings using the trade discrepancy tool and the viability of using it to find trends that indicate potential illegal activity.

## Chapter 2. Discrepancy Factors

The analysis of trade discrepancies in forest product trade data has been a focal point for many researchers in attempting to pinpoint sources of illegal activity or to make recommendations to policy makers on the appropriate methods of limiting it. Depending on the relationship and policies of the countries involved in the trade and several other variables, trade discrepancy can be the result of ordinary shipment delays or other statistical errors, and not just illicit activity. It is important to bear this in mind when comparing trade data between countries while attempting to find illegal trade patterns, as trade discrepancy is to be expected within certain limits (Makhoul & Otterstrom, 1998).

There are several benign and illegal factors that frequently affect the level of discrepancy in the trade of forest products. Benign causes of discrepancy include shipment time lag and differences in scaling, unit conversion, Harmonized System (HS) code use, or the valuation of shipping costs. Benign errors like these are typically identifiable and consistent. Illegal causes of trade discrepancy include misreporting, misclassification, and smuggling (Eastin & Perez-Garcia, 2004). The benign factors that contribute to discrepancy are difficult to avoid but can often be identified and mitigated. The illegal factors are more concerning as they are associated with activities that are economically and environmentally harmful (Blundell & Mascia, 2005).

### *Benign Discrepancy Sources*

Countries sometimes use different methods of measuring the volume of the product that can be incompatible with the methods used by the trading partner. For example, when measuring timber logs, the United States may express the volume measurements in cubic feet, board feet,

cords, tons, linear feet, or pieces (*Log Scaling,* 2021), while countries in the European Union usually give volume measurements of logs in cubic meters (*Forest Products Conversion Factors,* 2020). A country may even have its traditional measurement units, like the Japanese koku, which is also used to measure timber logs (Briggs & Flora, 1991). While there are many conversion methods used to accommodate for the use of various volumetric units, mathematical errors, or slight inaccuracies in the conversion techniques themselves can contribute to trade discrepancy.

Harmonized System (HS) codes are used for the international trade of goods to provide a shared classification system that ranges from more generic 4-digit codes to 12-digit codes that can be specific to a single country. The system is "harmonized" to the 6-digit level, meaning that almost all countries around the world use the same descriptions for 2-, 4-, and 6-digit codes. But thereafter, from 8-12 digits, there can be differences across countries. In the forest products category for example, logs are classified with the HS code 4403 and lumber or other processed wood products are classified with the code 4407, with more digits added for more specific species and product types of logs or lumber. This system can still be a source of trade discrepancy, as each country could use different descriptions of 8+ digit codes, causing the potential for classification error. This potential discrepancy source seems more likely when considering that customs officials may not be able to accurately identify individual species or product types well enough to be able to catch these types of errors (Eastin & Perez-Garcia, 2004).

Inaccuracies in trade data resulting from HS code error are exemplified by the issues in the trade of wildlife, including tree species. Customs authorities do not have a required, standardized system for reporting species information in traded wildlife, which leads to inaccuracies that leave species data mostly irretrievable (Gerson et al., 2008). While the HS code

system is applicable for describing and quantifying broad taxonomic classifications of traded wildlife, incorrect usage of an HS code or confusion around some countries use of lengthier HS codes can often lead to problems with data collection and cause discrepancies between regulatory authorities like Customs and the Convention on International Trade of Endangered Species (CITES) (Blundell & Mascia, 2005). There is sometimes a severe lack of understanding in Customs and Border Control on how to appropriately apply HS codes to the trade of wildlife goods. Research by Gerson documents how there are major HS code errors in Canadian customs data involving wildlife products ranging from aquatic wildlife and shark fins to tropical wood. Canadian customs officers are generally able to physically inspect only about 2% of the commercial shipments entering the country and are not trained in identifying species or being familiar with their names. As a result, customs agents are very dependent on HS code classifications of wildlife products, which may be incorrect due to confusion about species. The HS code system was developed to be used for mostly tariff purposes and was not designed to be able to fully encompass the specifics of the species information that is necessary in the trade of wildlife (Gerson et al., 2008).

The allocation of shipment costs is another expected cause of some trade discrepancy, as it leads to differences in how the importer and exporter value the product. In most cases, export shipment costs are based on the free on board (FOB) value, while the imports are based on the cost, insurance, freight (CIF) value. FOB values include both the value of the goods and the value of services provided in the process of moving the goods to the border of the exporting country. In contrast, CIF value includes the value of the goods and services needed to get the products to the exporting country's border and the value of services needed to move the goods from the exporting border to the importing country's border. However, it should be noted that

some countries do not follow this standard method of FOB-CIF export and import valuation (*Trade valuation (CIF, FOB, Trade valuation, trade value)*, n.d.). Various researchers have shown that the mismatch between exporter and importer transportation costs can account for certain percentages of the total trade discrepancy. Since the methods of evaluating shipment costs differ, factors such as shipment distance, cheap back haul options (such as through returning empty container vessels), product type and transportation type can all influence how great this cost difference will be (Eastin & Perez-Garcia, 2004). With these factors affecting FOB-CIF shipment costs, the percentage of discrepancy that can be attributed to these cost differences can be highly variable. Worldbank estimates that FOB-CIF differences may account for about a 10% to a 20% difference in discrepancy values, while imports are typically more accurately recorded since they generate tariff revenues whereas exports do not, and that data quality may also vary depending on the country (Worldbank, 2010).

The amount of time it takes to ship goods from the exporter to the importer also contributes to discrepancy to varying degrees. A long trip needed for the shipment to reach its destination can result in the importer reporting the trade data in a later financial period than the exporter, who would report the data after it leaves the exporting country. This time lag is especially influential on trade discrepancy when it happens between data reporting periods. If a shipment of goods leaves the exporting country in the first fiscal quarter but isn't received by the importing country until the second fiscal quarter, each side of the trade shipment would be recorded in different quarters, increasing the discrepancy in both of those quarters. (Eastin & Perez-Garcia, 2004).

The role of lags in shipment times has been the subject of recent research involving the trade discrepancy in Chinese log and lumber trade statistics, which points out that while

shipment issues are often considered sources of discrepancy, the time lag between when exports and imports are reported is sometimes not. The delay between when exports and imports are reported, and the effect it has on the trade statistics, can be determined by investigating the recorded dates of the imports and exports from each respective country. However, this would require open access to sufficiently detailed customs documents of both countries involved, which is usually not always an available option. In place of this, Liu et al. show that after accounting for other measurement and shipment factors, it is possible to develop a time lag formula to effectively estimate the role of shipment and reporting time lag without fully relying on open access to detailed customs forms (Liu et al., 2020).

The study by Liu et al. into using a time lagged function to better investigate Chinese log and lumber trade statistics shows that there are methods for appropriately accounting for many of these benign systemic trade errors, which in turn would allow for more noticeable discrepancy resulting from illegal sources. The analysis of Chinese trade discrepancy with the time-lagged function included show that trade with China's major partners like Russia and the United States had lower discrepancy, while discrepancy remained high with some of the other (mostly tropical) countries. Tropical countries like the Philippines or Ghana were shown to have higher discrepancy due to mis-labeling or misreporting, but these higher discrepancy countries' trade flows had lessened with China over time as government policies have changed (Liu et al., 2020). This also highlights the important impact that government policy has on preventing these illegal sources of discrepancy.

Another factor that may have some effect on the discrepancy values present in trade data is the currency exchange rate. A study investigating 96 industries that export from the United States and import to South Korea showed that the Korean imports were much more prone to

effects of exchange rate when compared to the US exports (Bahmani-Oskooee et al., 2013). The study investigates this topic to highlight the importance of using the cost of insurance and freight measurement for shipping costs as well as the importance of converting values to US dollar amounts. Bahmani-Oskooee notes that the changes in exchange rate are not very noticeable in trade data when the data is aggregated and because of this, recommends that trade data be analyzed within bilateral trade flows and disaggregated types of goods. Analyzing the trade flows of multiple countries together and all types of traded goods at once would conceal any singular effects within a massive amount of data and would therefore go unnoticed (Bahmani-Oskooee et al., 2013).

Another source of benign trade discrepancy that could occur is inaccurate or lost information regarding the source of the goods when they are received by the importer. If a shipment of goods arrives at the importing country's port being carried by a vessel from a country that is different than the exporting country, the shipper or the receiving customs officials may incorrectly report the shipments country of origin. Shipments carried by Liberian and Panamanian vessels for example, tend to incorrectly show the country of origin as Liberia or Panama when the exports are in fact from a different country. Issues with incorrect or unknown origin or destination can also occur in the case of entrepot trade, since it involves the goods being reshipped through a third country. A country like Singapore, that frequently is involved in transshipment situations, can frequently be mistaken for the exporting country when the goods reach their destination. Studies of the hardwood lumber trade between the United States, Canada and the European Union showed that about 10-20% of exports from the US to Canada were re-exported to the EU without being further processed in Canada, causing the US hardwood lumber shipments to be reported as Canadian exports by Canada while being reported as US exports by

the EU. These triangular trade scenarios can have an impact on the trade discrepancy between countries, especially where larger trade volumes or values are concerned. Sometimes, unintentional paperwork errors or lost paperwork can result in a country reporting the shipments being traded with an unidentified country, further complicating issues with discrepancy. Eastin and Perez-Garcia give an example of the plywood trade from Russia, where about 6.1% of the plywood exported by Russia was traded to an unidentified country. In 2001 the unidentified partners accounted for the 6$^{th}$ largest plywood trading partner with Russia (Eastin & Perez-Garcia, 2004).

*Illegal Discrepancy Sources*

By considering these sources of unintentional error they can appropriately be accounted for or mitigated, and trade discrepancies can be more accurately analyzed to pinpoint illegal factors of discrepancy. The first of these illegal factors is the misreporting or misclassification of goods, which is especially prevalent in countries that have over-valued or non-convertible currencies and restricted access to foreign exchange or foreign currency (Eastin & Perez-Garcia, 2004). These characteristics being present in a country provide the importer with an incentive to attempt to get the shipment under-valued or mislabeled, with the exporter receiving some of the kickback and providing them with incentive to cooperate with the under-valuing or mislabeling of the product. Typically, under-valuing or mislabeling a product can mean misclassifying the type of product, such as claiming a value-added product is less processed one, or by misclassifying the species that the product is derived from. High taxes and tariffs or an import quota system can further exacerbate this issue by providing even more incentive for importers and exporters to participate in illicit trade.

Illegal causes of discrepancy in the wildlife trade, of which timber makes up 65%, often results in harmful environmental impacts (Blundell & Mascia, 2005). The Convention on International Trade of Endangered Species (CITES) regulates or prohibits the trade of many endangered or protected species, yet trade discrepancies still occur because of importers and exporters attempting to get around trade restrictions. Examples of trade discrepancy within international trade data monitoring systems resulting from mis-categorization, unitless data and mismanagement of data, suggest that illegal activity involving CITES species is widespread and likely much more prevalent than indicated by official statistics (Blundell & Mascia, 2005).

While an entrepot (triangular trade or having a middleman) trade pattern is a benign factor for trade discrepancy, it can hide sources of illegal discrepancy if it is assumed to be the only discrepancy source. Trade discrepancy between the US and China has often been attributed to the role of Hong Kong as an entrepot between the two countries, however further examination has shown evidence of exports being misreported at the Chinese border to avoid value-added tax, tariff evasion at the US border, and inaccurate transfer pricing and evasion of Chinese capital control measures (Ferrantino et al., 2012). Inaccurate transfer pricing is when the value of a transaction is set to an artificially high or low amount with the intent to affect an income payment or capital transfer between two organizations (*Oecd glossary of statistical terms—Transfer price definition*., n.d.) The amount of Hong Kong re-exports originating from China and going to the United States had also decreased from 61% of total reported US imports from China in 1995 to less than 12% of the total US imports from China in 2008. Meanwhile, the discrepancy from Chinese exports going directly to the US without going through Hong Kong had increased from a value of $1.7 billion in 1995 to about $39 billion in 2007. The role of Hong Kong as a China-US entrepot having decreased, and the amount of discrepancy in bilateral trade

between the US and China having increased, suggests that the discrepancy has been a result of other factors and not necessarily due to trans-shipment through Hong Kong. Instead, the values of shipments are likely being misreported, being undervalued with Chinese customs, overvalued with US customs or both (Ferrantino et al., 2012).

Additional research found that Chinese exports were often under-reported when compared to the imports reported by the partner countries and that Chinese imports were over-reported when compared to the exports of the partner countries. Chinese traders also used a method called round-tripping, where funds are moved from mainland China through trade to Hong Kong or somewhere else off-shore, then re-introduced to mainland China as foreign investment. Doing this allows these trading firms to benefit from the preferential tax treatments that are typically afforded to foreign investors by the Chinese trade policies and this sort of trade behavior constituted a significant portion of foreign investment into China at the time the research was conducted (Fung et al., 2011).

To look for discrepancies caused by misreporting between China and Hong Kong, Fung et al. disregarded statistics involving Hong Kong as an entrepot and solely compared the direct trade flows for each country involving goods at the six-figure HS code level. Since Hong Kong did not have any tariffs, there is little incentive for traders to misreport trade figures in Hong Kong, so these statistics were believed to be accurate and made for a suitable comparison for the discrepancy in the Chinese trade data (Fung et al., 2011). In their findings, there was a very large amount of discrepancy between Chinese trade statistics and those of Hong Kong. The discrepancy values were also mostly positive, indicating that most of the discrepancies were coming from the Chinese side of the statistics. These findings suggest that much of the discrepancy present in this data was due to illegal activity. If the discrepancies were caused

solely by statistical error, the amount of discrepancy between China and Hong Kong would not be as large as the results found by their research, and the discrepancy values would be a mixture of positive and negative values since the errors would have a similar chance of occurring on both ends of the trade flows. Based on these results, it was suspected that the discrepancy between the China and Hong Kong trade data is likely due to intentional misreporting of more highly taxed products as other products to avoid import taxes (Fung et al., 2011).

Smuggling is another illegal cause which may result in trade discrepancy, although in most cases of smuggling the trade information is typically not reported at all and therefore it likely does not have an obvious presence in the trade data. Smuggling is most likely to occur in the case that the wood was illegally harvested or is from a species of tree protected by CITES. In some cases, smuggled forest products may receive falsified documentation to reach their destination more easily. This would cause these smuggled shipments to be reported along with legitimate imports by the importing country but as these shipments would not have been reported as exports at any point, they would lead to a mismatch in the import and export data. Smuggling with the use of falsified documentation would require a third party, either a corrupt government official or some other entity capable of forging these legal documents and would most likely occur with trade routes that require the shipment of goods by vessel. In situations where the wood products are smuggled across land borders, falsified documentation may not even be needed as it is much easier for smugglers to bypass ports and customs authorities altogether. As a result, smuggling across land borders is likely to have almost no impact on trade discrepancy, as there would be no reported data on the shipments at all. Econometric methods have been used to show illegal trade from smuggling through trade discrepancy in the forest sector, but the results seemed to show that the ability to do so is limited (Vincent, 2004).

**Table 1.** Summary of factors that could affect discrepancy in the trade of timber products

| **Benign Factors** | **Description of Factors** |
|---|---|
| Statistical or Measurement Error | • Errors resulting from conversions between different measurement units [ (*Forest Products Conversion Factors,* 2020), (Briggs & Flora, 1991)]<br>• Errors in conversion of currency (Bahmani-Oskooee et al., 2013).<br>• Differences in log scaling methods between the importer and exporter *(Log Scaling,* 2021)<br>• Unintentional errors in data collection by customs officials |
| Errors in Regulation | • Exporter and Importer may use different HS classification code or number of digits in the HS code of a product<br>• Customs officials may not be able to identify species or product type adequately enough to correct errors (Gerson et al., 2008) |
| Shipment Issues | • The method of allocating shipment costs creates some discrepancy in trade values between importer and exporter (*Trade valuation (CIF, FOB, Trade valuation, trade value)*, n.d.)<br>• Products exported within one time-period may not arrive to the exporter until the next, this is common in sea shipping (Liu et al., 2020)<br>• Transhipment, where a product goes through a third country on the way to an importer, may cause confusion with reporting country of origin (Ferrantino et al., 2012).<br>• Triangular (entrepot) trade can also contribute to confusion about country of origin (Ferrantino et al., 2012). |
| **Illegal Factors** | **Description of Factors** |
| Misreporting | • Exporters or importers may misreport trade volumes/values to evade government regulations or restrictions on a product (Eastin & Perez-Garcia, 2004)<br>• Exporters or importers may misreport trade volumes/values because of an economic |

| | |
|---|---|
| | incentive such as avoiding a tax or tariff (Eastin & Perez-Garcia, 2004) |
| Misclassification | • Species or product type may be misclassified to bypass checks for legality (Eastin & Perez-Garcia, 2004)<br>• High tariffs or restrictions on a species or product may incentivize traders to misclassify a product (Eastin & Perez-Garcia, 2004) |
| Smuggling | • Rarely affects discrepancy since successful smuggling typically avoids customs authorities completely (Vincent, 2004) |

## Chapter 3. Using Discrepancy Analysis

A recent study into the illegal timber trade in Peru shows how trade discrepancy analysis can be used effectively in the forestry sector. Trade data for Peruvian timber showed a consistent trend of under-valued exports being sent to Mexico and the United States, which could indicate under reporting to avoid import taxes in these countries. There was also a trend of over-valued timber exports being sent to China and the Dominican Republic, possibly a sign of export incentives being taken advantage of. While trade discrepancy can be the result of simple statistical error, when discrepancies occur repetitively, like these trends found by Pardo-Herrera, they are useful warning signs that there is likely illicit activity occurring in the trade flows concerned (Pardo-Herrera, 2021). The data collected in the Peruvian timber trade with the Dominican Republic shows an especially glaring example of fraudulent data. Not only was there a pattern of discrepancy with reported trade, but the amounts of timber supposedly being imported from Peru by the Dominican Republic exceeded the countries' estimated levels of internal consumption of timber. Pardo-Herrera points out that the role being played by the Dominican Republic in this timber trade is still unknown, but this is a good example of how trade discrepancy analysis can shed light on previously unknown patterns of illegal timber trade activity (Pardo-Herrera, 2021). With distinct regulations that apply to certain timber products,

coupled with the sometimes-ambiguous legal definitions of these products, mislabeling of some of these traded goods may seem like a low-risk way of avoiding restrictive controls and making more money to timber traders.

In addition to the changing trade policies that could be influencing illicit activity, the evolving demand for timber products warrants maintaining a watchful eye for any sign of these activities, so that decision makers can take appropriate action before environmental and financial problems become even more damaging. The production and trade of wood products continues to rise every year and according to World Bank the demand for roundwood alone is estimated to quadruple by the year 2050 (*Forests Generate Jobs and Incomes,* 2016). Not only is rising demand a factor in possibly elevating illicit activity in timber trade flows, but the types of products and means of production is as well. In the past, sawn wood was traded more often than boards, planks, or other types of value-added wood products, but as the technology of the industry improves and becomes more available, countries are more likely to begin processing value added products within their own country before trading to improve their domestic economy and job market. Interviewees in the study conducted by Pardo-Herrera also mentioned that they believed that regulations for boards and planks were more lenient because of the increased ambiguity on how the different products are legally identified after being converted to a value-added product. The increasingly common trade of processed wood and the added leniency associated with this type of product would certainly act as an incentive for timber traders to intentionally mislabel products as lumber to avoid the stricter controls when shipping their goods (Pardo-Herrera, 2021).

According to Pardo-Herrera's research, between 2009 and 2018 Peru reported timber exports to Mexico that were on average 4.1 million USD less than the value of what Mexico had

reported for the imports. The timber products with the largest amount of discrepancy in this trade flow were chipped wood and laminated wood. The value discrepancy and the types of wood products where these discrepancies mostly occur, imply that traders may be intentionally undervaluing exports of wood products that are more difficult to identify to avoid certain import taxes in Mexico. A further implication of this is that Peruvian exports are likely being undervalued in other trade flows involving similarly processed timber products as well. Pardo-Herrera points out that this under-reporting activity could also be used as a method to conceal profits, conceal laundered money from criminal activity or to take advantage of fluctuations in exchange rates by reporting a lower value for the products than what they will likely sell for later.

On the other hand, importers can also profit from situations like this timber trade flow between Peru and Mexico. Over-reporting the import quantities coming into a country, to reduce per unit values, can be used to avoid import taxes, avoid currency controls or profit from foreign exchange rates. In the case of the previously mentioned trade flow between Peru and Dominican Republic, the import values were not suspicious, instead the quantities imported by the Dominican Republic greatly exceeded the estimated internal consumption of the country and these excessive quantities were not being re-exported according to customs declarations (Pardo-Herrera, 2021). Supplementing this suspicious activity, investigations by the Environmental Investigation Agency (EIA) have shown that the Dominican Republic has previously played a part in international timber laundering operations (Urrunaga et al., 2012). In the trade flows between Peru and China, China was shown to have reported imports that were double the amount of sawn or chipped wood that Peru had reported as exports. In this case, China had reported all the imports from Peru as sawn or chipped wood, regardless of what Peru had reported the

shipments as, creating discrepancy. A more important issue also existed in this same trade flow, the values of these exports leaving Peru were generally over-reported at significantly higher values than those reported by China. (Pardo-Herrera, 2021).

Over-reporting of exports can also be done intentionally for reasons related to fraudulent activity. By falsely claiming that the value of the exports is higher than what the importer is paying, exporters can take advantage of certain incentives like export subsidies. Peru has maintained a trade policy called the Restitution of Tariff Rights or the "drawback" tariff since 1995. This policy allows traders to receive a refund of the taxes during the export processes related to shipment loading costs, shipping costs and production and the Peruvian government does not audit the trading companies that receive these export benefits. The Peruvian government has policies in place that require proper documentation of legal origin for the products being exported but the products themselves are not inspected (Gomez and Blue Sky, 2017). In other words, an exporting company that can acquire the correct required documentation, could easily claim that the product is legally sourced and that the value of the exports is higher than what they will actually receive, resulting in a larger amount of exporting taxes returned to them with a low risk of being caught. A pattern of consistently under-reporting imported goods is a general indicator of avoiding import taxes or customs duties while also allowing a form of money laundering by way of providing a greater currency or resource flow into the country than what is being reported. In a similar fashion, under-reporting of exports also allows for a method of tax evasion and money laundering (Pardo-Herrera, 2021). In summary, both exports and imports can have their values manipulated to be under-valued or over-valued for evading different regulations and to save or earn more money.

The timber trade flow between Peru and the United States included previously mentioned indicators of suspicious activity as well. Despite there being no notable increases in investment into the Peruvian timber sector, there was a substantial increase in the reported exports of timber to the US. Pardo-Herrera suspects that this is likely due to the mislabeling of wood as the wrong species or products type to avoid regulations that only apply to the actual product, and intentionally misreporting the products as high value to benefit from the export subsidies offered by the Peruvian government. Peru reported the total wood exports to the US during the period studied to be over 26.2 million USD, which would account for a total of about 12% of Peru's total exports to the US. Yet the US reported very little imports of timber from Peru during this time, showing another example of fraudulent trade activity in the data (Pardo-Herrera, 2021).

Discrepancies like the ones identified in the Peruvian timber trade data may not necessarily be the result of corruption or illicit activity in every instance, however even if they are not, the presence of incentives to misreport trade data and the relative ease in which traders could potentially do so is important information to be aware of. Having this knowledge from trade discrepancy analysis could allow authorities to more effectively engage in investigations of traders that are more likely to commit violations or to better inspect documentation, leading to decreases in illegal activity, discrepancy from illegal activity and in the case of environmental products like timber, benefits to the environment. Even if large discrepancies in a trade flow were the result of statistical error, if these incentives and regulation loopholes exist, the potential to be taken advantage of also exists and should be brought to the attention of policy makers so that it can be prevented. In the case of the Peruvian timber trade data, a seemingly large source incentive for fraudulent trade activity are the limitations in the ability to identify and differentiate between certain timber products, whether that be from more specific legal definitions of how

products are defined (like through HS codes) or some sort of training to better enable customs authorities to be aware of this intentional product mislabeling. Essentially, trade discrepancy analysis can not only be used to estimate if illegal trade activity is actively occurring, but in some cases may be used to find areas of trade where there is the potential for these activities to occur.

This study intends to look for patterns of trade discrepancy like what was done in Pardo-Herrera's research, but on a broader scope. Instead of focusing on one country and its trade partners, the goal is to create a global picture of trade discrepancy patterns and highlight potential areas of concern. These areas of concern can then be further investigated for the exact causes of the discrepancy and determine what actions need to be taken to address them.

## Chapter 4. Data Overview

*Trade data source*

The data used in this study were obtained from Trade Data Monitor (Trade Data Monitor LLC), a database of trade information retrieved from the government customs or statistics agencies of each country represented. Data on exports being shipped to another country are reported by the exporting country's government agency, while the imports from that same exporter are also reported by the importing country's government agency, allowing for comparisons to be made between the two. Discrepancy trends between the imports and exports and market share trends were analyzed to estimate the risk of illegal activity in bilateral trade flows. A total of 70 countries are represented in TDM for the trade of wood products, with reported data going back to as early as 1991. The traded goods are classified using the Harmonized System (HS) and include data on the quantity and value of the imports and exports

for each country. With data from 70 countries that trade wood products internationally, it is possible to develop a general overview of the global trade flows involving wood products.

*Data Collection*

The TDM dashboard enabled data queries that were based on the settings from 15 fields (Table 1). Of those fields, the trade flow, reporter, and HS code sections were manipulated to collect data for each country and product type. Specifically, these queries were used to collect export and import data from each reporting country for logs (HS code 4403), lumber (HS code 4407), and plywood (HS code 4412). Aside from the time period field being set to 'annual' for all searches, other search fields remained in their default search criteria as they did not need to be changed between queries. The 'annual' option for the time period parameter was used for all queries to minimize the effect of shipment time lag, which is the difference in the time period reported for a shipment by the importing *versus* the exporting country. For example, the average transportation time between China and its trade partners has been shown to range from 0.23-1.34 months (Liu et al., 2020). If a discrepancy analysis is conducted for each financial quarter, some of these shipments may leave the exporting country during one quarter while arriving at the importing country during the next, creating higher discrepancy in both quarters. Thus, to mitigate the impact of shipment lag on discrepancy in this study, discrepancy was calculated for annual data. While some discrepancy from shipment lag is still to be expected between December and January, analyzing annual data substantially reduced discrepancy resulting from shipment lag in comparison to calculating discrepancy by financial quarter. Such a lag time is expected when the shipment travels greater distances, experiences adverse weather conditions, or has issues with custom clearance processes or along the shipment route. Differences in the reporting time frame

between the exporter and importer can contribute to a higher discrepancy value if the difference in reporting crosses the threshold between time periods considered when calculating discrepancy.

The compiled datasets consisted of six master files, which included: (1) exports of logs, (2) imports of logs, (3) exports of lumber, (4) imports of lumber, (5) exports of plywood and (6) imports of plywood. Each row of each master file included the reporting country and corresponding partner country, and the traded product value in US dollars for each year, from 1991 to 2020. Product values were used instead of their volume to avoid conversion errors from differing units of volume between countries and inaccuracies in scaling methods, like the Scribner scale, that are used to estimate volumes for logs (Spelter, 2004). Additionally, when querying data, a customized group was made in TDM named EU 27 Brexit that includes all current members of the European Union since data from the EU is often reported together.

**Table 2.** Summary of the TDM dashboard. (A) Labels for each data field, (B) possible query options in each data field, and (C) query options selected to generate the master data files.

| **(A) TDM Data Field** | **(B) Field Options** | **(C) Options Used** |
|---|---|---|
| Trade Flow | Imports, Exports | Imports, Exports |
| Reporter | Global view, list of country names | Each country named in the list |
| Partner | All partners, list of country names | All partners |
| Partner Group Options | Normal, exclude members, exclude non-members | Normal |
| List By | Reporter country, partner country, HS heading | Reporter country |
| HS Code | List of HS codes | 4403, 4407, 4412 |
| Level | Next, 4-D, 6-D | Next |
| Product Group | Not selected, List of all product groups | Not selected |
| Time Period | Monthly, quarterly, bi-annual, annual, year end | Annual |
| Statistics | Value, quantity | Value |
| Currency | List of currencies | United States Dollar |
| Quantity | 1st unit, 2nd unit | 1st unit |
| Conversions | Deactivate, dozens, general, kilogram, tons | Deactivate |
| Precision | Billion, million, thousand, one | One |
| Language | List of languages | English |
| Numeric Format | American, European | American |

# Chapter 5. Methods

*Trade discrepancy and risk calculations*

With product values from each exporter/importer and its trade partners, iterative calculations in R were used to find the discrepancy in each trade flow. In each individual comparison between an exporting country and each of its partnering countries, the percent trade discrepancy (D) was calculated as:

$$\mathrm{D} = \frac{E - I}{Max(E, I)} * 100$$

Eqn 1

where *E* is the value reported for a given product by the exporting country, *I* is the value reported for a given product by the importing country, and *Max[E, I]* is the value of either the exports or the imports, whichever is greater. For example, a situation where country X reports exporting $1000 of logs to country Y, but country Y reports receiving $500 of logs from country X, would be ((1000 – 500) / 1000) X 100 resulting in a trade discrepancy of 50% for a particular year. This discrepancy equation was used for every comparison between importer and exporter and for each product type.

The discrepancy values could be positive or negative and range from -100 to 100. Values at or close to 0 have the lowest discrepancy, indicating that the value of exports and imports in a trade flow were the same (see Eqn. 1). Conversely, a scenario where one side reported any non-zero value while the other reported a trade value of $0 would result in a discrepancy value of 100, indicating maximum discrepancy. The discrepancy values can also maintain a positive value (export value > import value) or a negative value (export value < import value). The positive or negative sign on a discrepancy value solely indicates the direction of the discrepancy. Values of

50% and -50% are the same level of discrepancy but express whether the exporter or the importer reported the higher value.

This study also considers the portion of the market a trade flow occupies. A trade relationship that has a 100% discrepancy but only traded a small value of lumber one time is as likely to be the result of error as it is to be from illegal activity. To avoid focusing on these instances, the data must be normalized because the market share of a product will vary between countries. This research intends to highlight trade relationships that have high discrepancy as well as frequently trading high values of a product. The country market share (*M*) that a particular trade flow occupies was calculated as:

$$M = \frac{P}{A}$$

Eqn 2

where *P* is the total value of a traded product (i.e., import or export) with the partner country and *A* is the total global value of a traded product (i.e., import or export) for that same year.

An evaluation of risk for illegal activity in a bilateral trade flow requires the consideration of both the discrepancy and the market share. Dividing an individual trade flow's value by the value of trade with all partners gives the portion of the country's market that its trade partner occupies. A trade flow with a greater market share and high discrepancy is more likely to have greater or more frequent amounts of illegal trade than a trade flow with a small market share and equally high discrepancy. To evaluate the risk of illegal trade, risk score(*R*) was calculated as:

$$R = D * M$$

Eqn 3

where *D* is the percent discrepancy between importer and exporter and M is the percentage of the exporter's market occupied by the importer (when using the map from the exporter perspective). When using a map from the importer perspective, the M is reversed, with it representing the percentage of the importer's market occupied by the exporter. A trade flow where that occupies 0.3% of the global export market (a high overall market share) and has a 100% discrepancy would result in a risk score of 30. Risk scores of 30 or above are considered highest risk, while scores near 0 would reflect minimal risk. The risk scores were calculated for each product type, for every year, and every available exporter and importer combination using another for-loop. This for-loop multiplied every cell in a discrepancy master file with its corresponding cell in a market share file to create a final file containing the assigned risk scores.

*Data processing, analysis, and visualization*

After collecting the six master files of the imports or exports of each of the products, the next step was to calculate the discrepancy. The use of a for-loop in R would run this calculation for every year of every possible combination of the 70 countries that have data reported for the given product type and put all the resulting discrepancy values into a master discrepancy file for that product, with the same format as the other master files. To determine the discrepancy for trade flows involving logs, the master files for the export of logs and the import of logs would both be used by the loop calculation, reiterating for each possible combination of importer and exporter, and generating a table of trade flow discrepancy for logs. Both sides of the trade relationship are necessary to determine the trade discrepancy, so trade flows considered in this analysis must have both the importing and the exporting countries trade data available.

The market share values were calculated next by dividing the appropriate export or import master file (export master file for the export map and import master file for the import map) by the global values for that same product. Global values were calculated by summing the annual values reported by each country for a given year. Each value within a year would then be divided by the global value for that same year to get each country's portion of the global market for that product. These market share values are part of the calculation process for the app code and don't have their own master file.

Finally, the risk for each trade relationship is calculated by multiplying the market share values by the appropriate discrepancy file. Both the discrepancy file and the global market share data table were arranged alphabetically beforehand to ensure that each cell was multiplied by its corresponding cell in the other data table. The resulting risk score data was matched to the world map data by country name and appended to the map data so that it will be shown on the map.

With the data files for each product type containing the calculated risk scores of all available trade flows, R Shiny (Chang et al., 2022) was used to display the data on choropleth world maps based on the inputs selected by the user. User selected criteria include the product type (selects which risk file to draw data from), the importing or exporting country (selects rows that contain the chosen country name in the 'Reporter' column), and the year range (selects year columns within the selected range). Risk scores within data cells fitting all selected criteria are displayed on the world map. Since the maps are generated based on the criteria chosen by the user, the choropleth map is adaptable and not limited to preset maps. The trade partners of the selected exporter or importer that trade in the chosen product and during the chosen year range will be filled in with a color corresponding to the risk score assigned to the trade flow it has with the selected country, ranging from a pale pink/off white color for minimal risk to dark red for

very high risk. The country chosen by the user and countries that are not trade partners, or that lack sufficient data to assign a risk score, will remain gray.

The first section of the app generates data on the map from the perspective of the exporter, while the second section generates maps from the perspective of the importer. Aside from the difference in perspective, the maps in these two sections function the same and display information in a similar format. It's worth noting that market share is different when looking at a trade flow from different perspectives, which would result in differing risk scores for the same trade flow when viewed from opposite ends. For example, in a trade flow from Country A to Country B, the risk score from the perspective of the exporter (Country A) is likely to be different than the resulting risk score from the perspective of the importer (Country B).

The third section of the app shows more in-depth data for the ten trade relationships for each product that have the highest risk scores based on data from 2014 to 2020. This time frame is used to give a more accurate representation of recent data trends after the implementation of FLEGT and EU timber regulations. Discrepancy score tables for each product type (which are distributed normally) each have their respective standard deviations included in the calculations so that any trade flow that falls within the range of -0.5 SD to 0.5 SD would not be considered as being a potential top risk trade flow. This is meant to prevent trade flows that have large market shares from being selected as highest risk based on their market share alone (since Risk = Discrepancy * Market Share). Instead, trade flows appearing in the top risk rankings will be based on both high discrepancy and high market share. The graphics in this section of the app display the results with three charts; a vertical bar chart showing the risk score associated with each of the top high risk trade flows, a plot showing the discrepancy scores in each trade flow, and a bar chart for the portion of the global market that is occupied by the trade flow. Each

graphic showing a piece of the risk calculation that determined these trade flows to be highest risk (discrepancy, market share and the resulting risk score). The charts for risk score and discrepancy both use green to show that the exporter reported a greater trade value and red to show the opposite.

## Chapter 6. Map Comparisons Overview

Map outputs for bilateral trade relationships with known or suspected trade issues were generated to compare the results with case studies of those same trade relationships in existing research. Generated maps use the average risk scale of 0 to 30 to indicate the risk of illegal trade taking place, with 0 (white/pale) being minimal risk and 30 (dark red/maroon) being very high risk. The date range used in this case is 2014 – 2020, to display data that includes the effects of relevant international policies and programs like FLEGT and EUTR. Maps were generated for cases of trade flows with known policy issues and/or have been the subject of previous studies for the sake of comparing results and determining the effectiveness of using discrepancy analysis and this tool. These case studies include exports from Ghana to India, exports from Indonesia to China and exports from Peru to multiple trade partners. The generated maps for each example support the findings of previous studies and match with what is expected from the trade patterns and policies for these regions.

*Ghana to India*

Ghana was one of the first countries to enter a Voluntary Partnership Agreement (VPA) with the EU in 2009 but as of December 2020 it was determined to not yet be ready for FLEGT licensing with some corrective actions needed. Ghana has historically been at high risk for illegal

trade and despite having logging export restrictions, corruption and weak enforcement has reduced its effectiveness, especially for high value species. Illegal logging in Ghana has reportedly declined due to its developing legality assurance systems, yet illegal harvest and trade continues (Forest Trends, 2021). There is little data indicating that Ghana exported plywood (4412) to India in this same time frame. The seeming lack of plywood exports in comparison to logs and lumber is likely due to the substitution of tropical plywood by softwood plywood in products like furniture, China becoming a major plywood exporter, and the strict quality and safety standards in major plywood markets like Japan and the EU (Amoah, 2009). Each of these factors likely inhibited the growth of plywood in Ghana during the development of its timber industry.

Since the 1980's, India has placed a heavy emphasis on conservation over production when it comes to its domestic forest use, with outright bans of any tree-felling in many parts of the country. As a result of the heavy restrictions on domestic logging, India heavily relies on imports of wood products to meet its demands, primarily in the form of logs. Lumber is also imported to a lesser degree while imports of products like veneer and plywood are negligible (Ghosh, 2016). India tends to keep import tariffs on logs low in comparison to tariffs on processed wood product imports to encourage the value-added production to take place domestically while conserving its domestic resources (Sood, 2019).

Ghana to India was selected as a test comparison because of the policy contradiction between the two countries. Ghanaian exporters are incentivized to report exporting lumber and not logs, while Indian importers are incentivized to report importing logs and not lumber. When generating the maps for exports from Ghana, trade flows to India were shown as very high risk for both logs and lumber. It should be noted that when generating maps for imports of logs or lumber to India (instead of exports from Ghana), Ghana is not shown as being very high risk.

This is due to the differences in market share. Exporters may have fewer trade partners than importers do, so an exporting country's trade partners will occupy larger portions of their market. In this case, since India imports high values of logs and lumber from many trade partners, Ghana doesn't occupy as much of India's total import market whereas India occupies a large portion of Ghana's export market. It would be best to generate maps from both exporter and importer perspectives of a trade flow to account for these differences in market share.

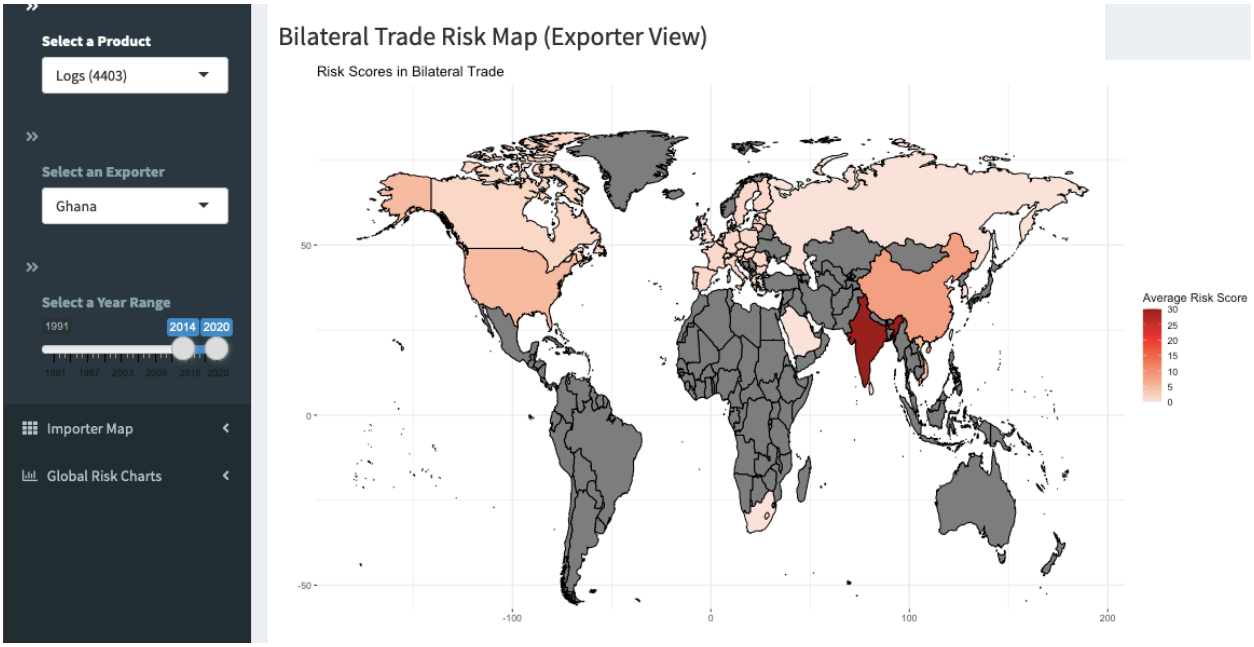


**Figure 1.** Map of log exports from Ghana, with India shown as very high risk for illegal activity.

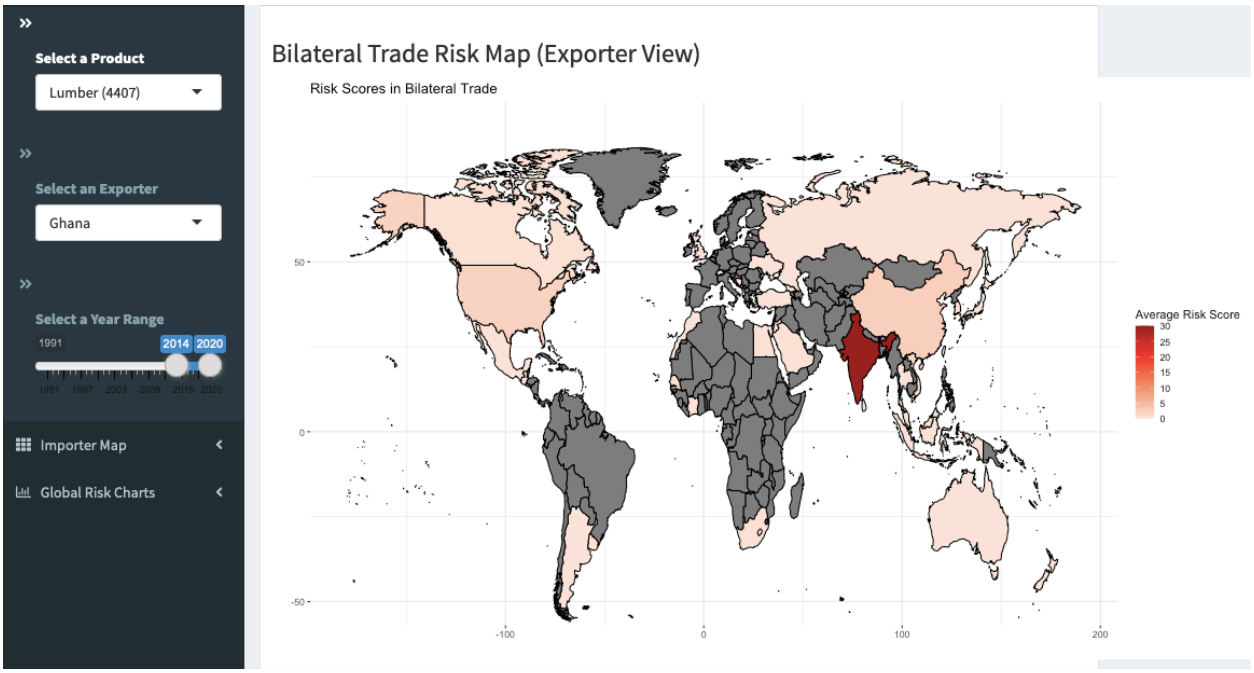


**Figure 2.** Map of lumber exports from Ghana, with India again shown as very high risk for illegal activity.

With the combination of both situations in Ghana and India, the very high risk of illegal trade between the two countries makes sense. Exporters in Ghana are likely to misreport logs as lumber to avoid Ghana's restrictions on log exports, whereas importers in India are likely to misreport Ghanaian lumber as logs to benefit from the reduced import tariffs. The discrepancy values calculated between Ghanaian exports and Indian imports for logs and lumber showed a nearly inverse trend from one another. Discrepancy scores of the log exports were high negative scores indicating that India was reporting much higher values than Ghana, while the discrepancy scores of the lumber exports were high positive values, suggesting that India was reporting much lower values than Ghana. The Forest Trends' chart of trade disparities between the two countries illustrates that between 2016 and 2019, Ghana had reported mostly exports of lumber while India had reported mostly imports of logs. Additionally, there is disparity in the value of the products being traded, especially in 2016, which would suggest that the value had also been misreported or may not have been reported by both sides.

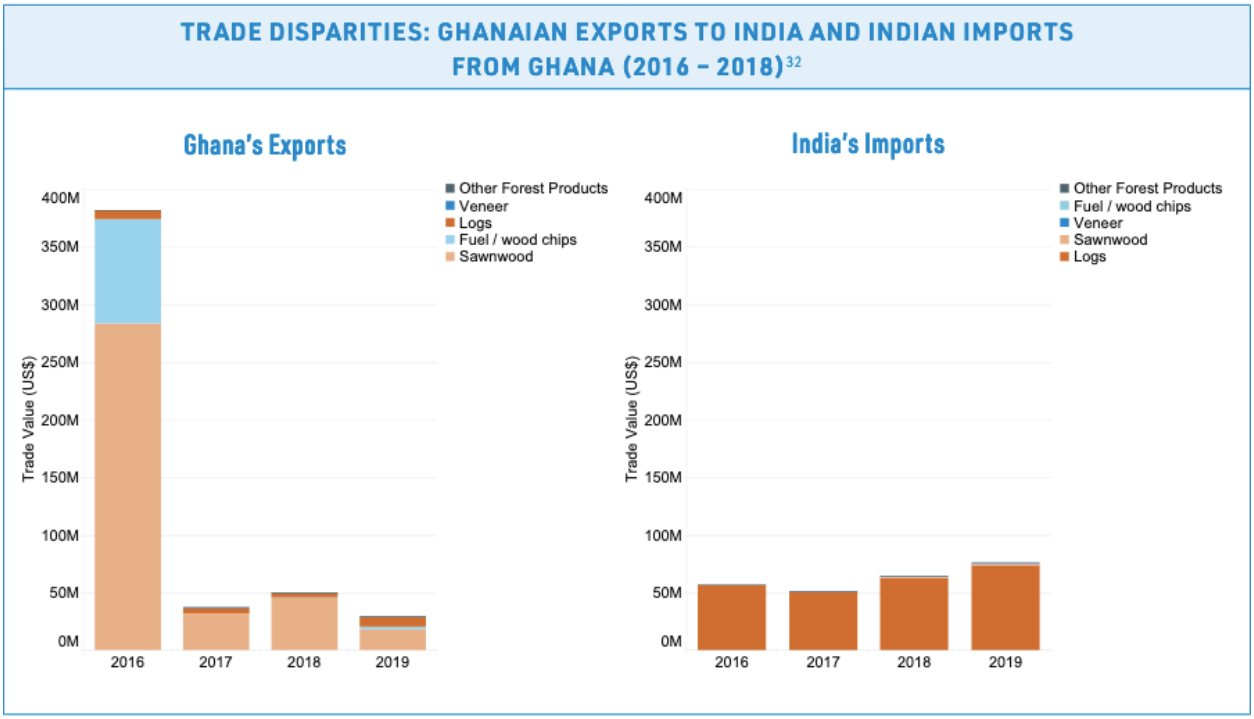


**Figure 3.** Forest Trends. *Timber Legality Risk Dashboard: Ghana*. 2021.

Overall, the maps generated for the trade of logs and lumber with Ghana as the exporter show the results that would be expected based on the policy differences and the incentives/disincentives from those policies. The research done by Forest Trends on trade disparities between Ghana and India also shows similar results to these maps with both countries reporting different products as well as misreporting product values. Including considerations for market share has led to differences in the maps for the same trade flow when looked at from different perspectives, in this case selecting India as the importer shows trade with Ghana as being low risk. Generally, it seems that including market share causes maps from the importer perspective to not be sensitive to detecting risk because importers often seem to have more trade partners, making the market share value used to determine risk much smaller. Checking both perspectives of a trade flow would be best but the map from the exporter perspective is more likely to indicate risk when it exists.

*Indonesia to China*

The trade of timber products from Indonesia to China is another trade flow that has been identified as one with high discrepancy by previous studies. The generated risk map for Indonesian log exports shows that there are not that many countries that import logs from Indonesia in recent years, and out of these countries, log exports to China show the highest risk of illegality.

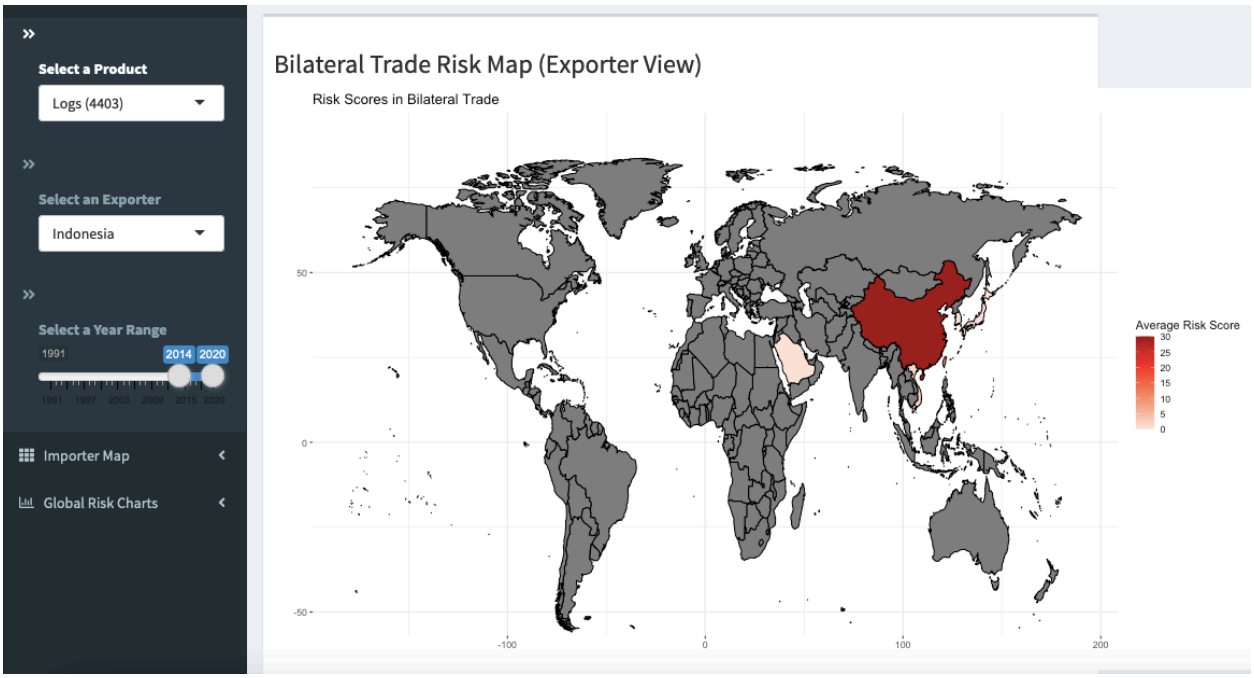


**Figure 4.** Map of log exports from Indonesia. China has a very high-risk score.

While Indonesia has more trading partners for lumber exports, China again showed very high levels of risk for this product compared to other countries.

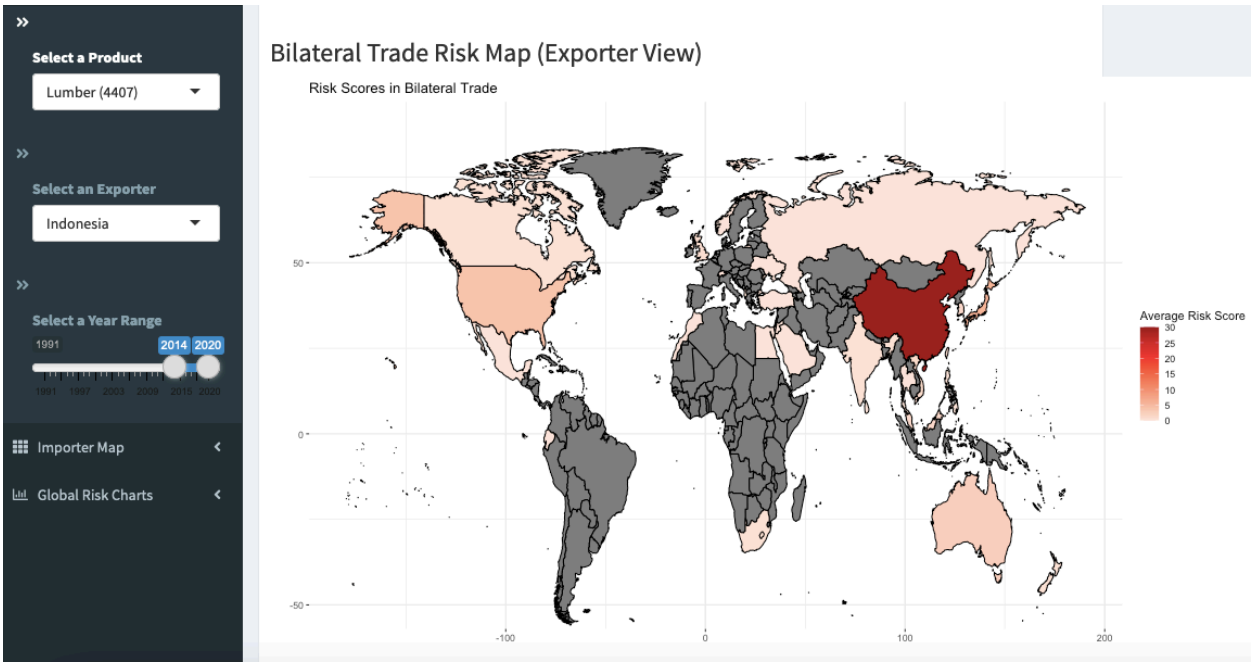


**Figure 5.** Map of lumber exports from Indonesia. China has a very high-risk score.

For plywood exports from Indonesia, China showed a moderate risk score but one that was higher than Indonesia's other trade partners.

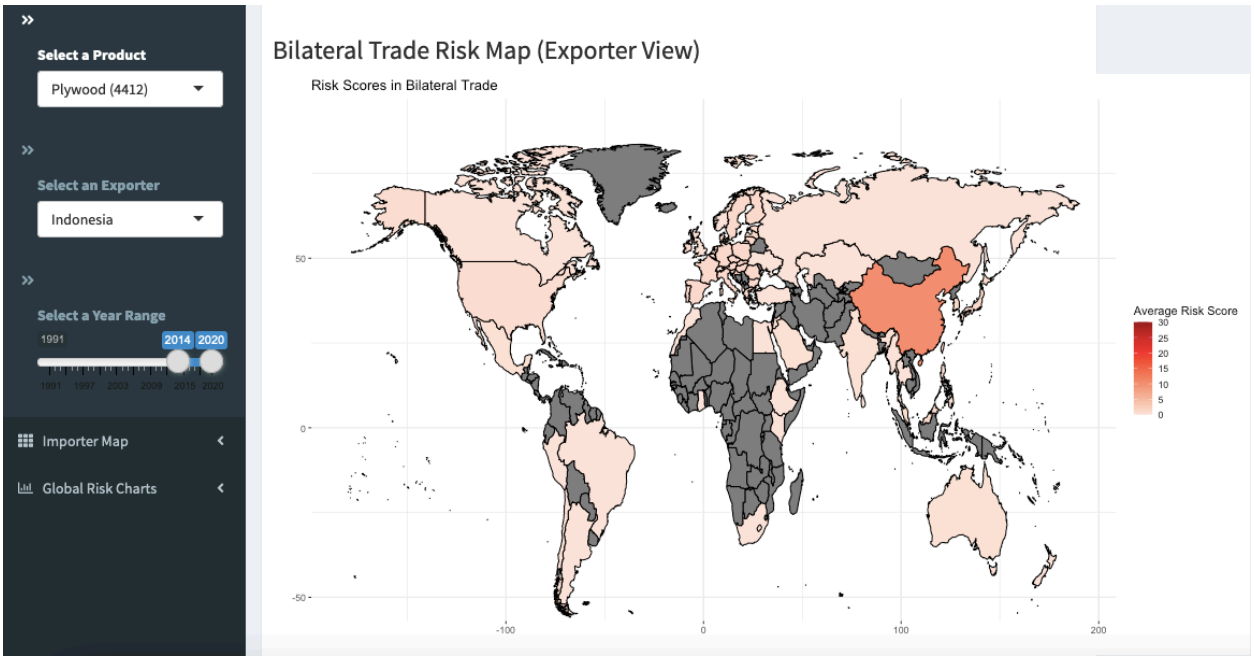


**Figure 6.** Map of plywood exports from Indonesia. China has a moderate average risk score.

Risk maps of the Indonesia to China trade flow from the perspective of China as an importer showed low risk for Indonesia in both logs and lumber and moderate risk for plywood. Like in the case with Ghana and India, this is due to the differences in market share. China as an importer receives logs and lumber from many countries, lowering the market share occupied by Indonesia. On the other hand, plywood also showed an average moderate risk score from this perspective because China imports less plywood from fewer countries, allowing Indonesia a larger portion of the market.

In Indonesia, a historical reliance on the timber trade as a source of revenue has led to degradation of its forest resources. There have been subsequent attempts to combat this degradation through national policies like a logging ban, export restrictions and participation in international programs like VPA and REDD+ commitments. However, prevention of illegal and environmentally harmful activity has often not been successful due to inconsistent governance, contradictory policy, poor enforcement, and legal loopholes (Stanovsky, 2021).

Since 1998, China has had very strict domestic forest protection laws to prevent the degradation of its own forests and making China one of the largest importers and consumers of timber products. China's imports of timber products from some tropical countries are at high risk of illegality. China revised its Forest Law in 2019 to ban the purchase, transport and use of timber known to be from illegal sources, however, there has yet to be any mention of due diligence measures included in this revision (Forest Legality Initiative, 2021). The combinations of China's high demand for logs and lumber, its strict domestic forest protections, and lack of due diligence measures for legally sourced imports coupled with Indonesia's inconsistent policies and poor enforcement of its own forest laws enable the exploitation of Indonesia's forest resources and the very high risk for illegality in the trade flow between them.

A study by Stanovsky on the illegality of Indonesian wood products evaluated the trade of logs and lumber from Indonesia to China as high risk and plywood as having been high risk between the years of 2012 and 2016. They also indicated that China is the second largest importer of Indonesian timber products (Stanovsky, 2021). The results of this research match those of Stanovsky's. While the map generated for plywood between 2014 and 2020 puts China at a moderate risk for illegality, adjusting the slider to the year range of 2012 to 2016 puts China at high risk for that period, corroborating the results found by Stanovsky.

*Peru to China, Mexico, the Dominican Republic, and the United States*

Peru has been known to have issues with illegality in its exports of timber as well. For the export of logs, China shows as the only trade partner with a very high-risk score.

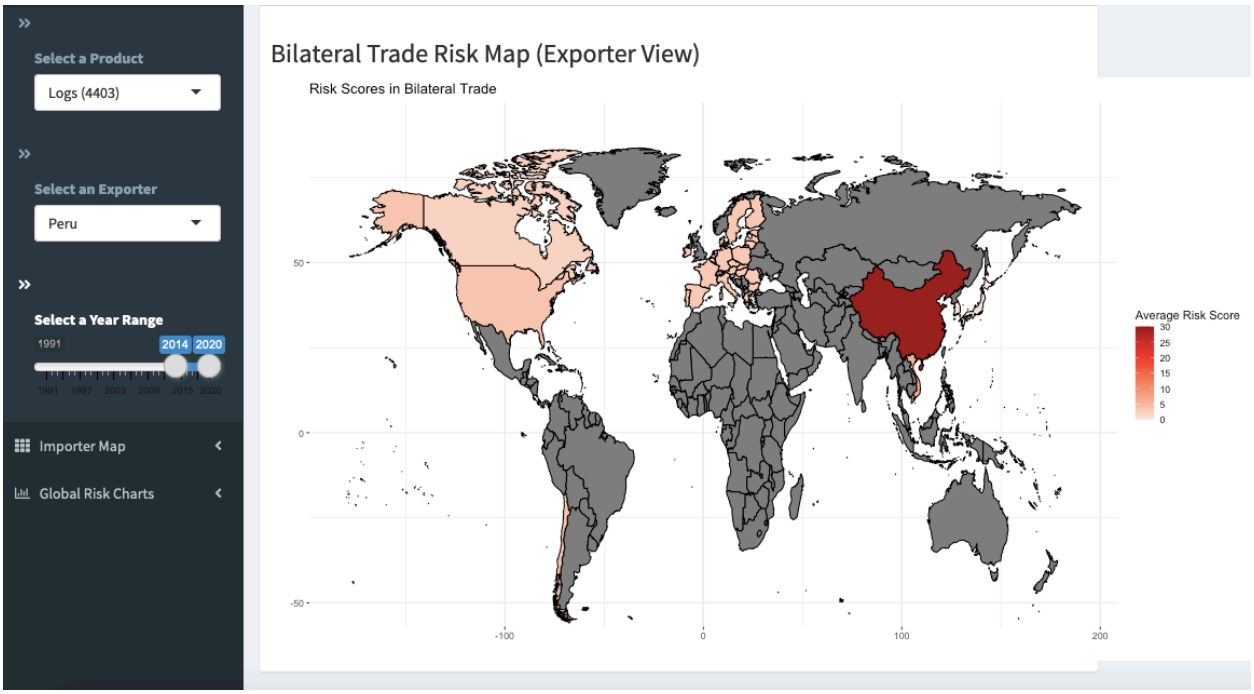


**Figure 7.** Map of log exports from Peru. Trade with China shows a very high-risk score.

Peruvian exports of sawn lumber are traded with more countries compared to its exports of logs but show a similar pattern with China being the only high-risk trade partner, however this risk is less compared to the risk associated with the exports of Peruvian logs.

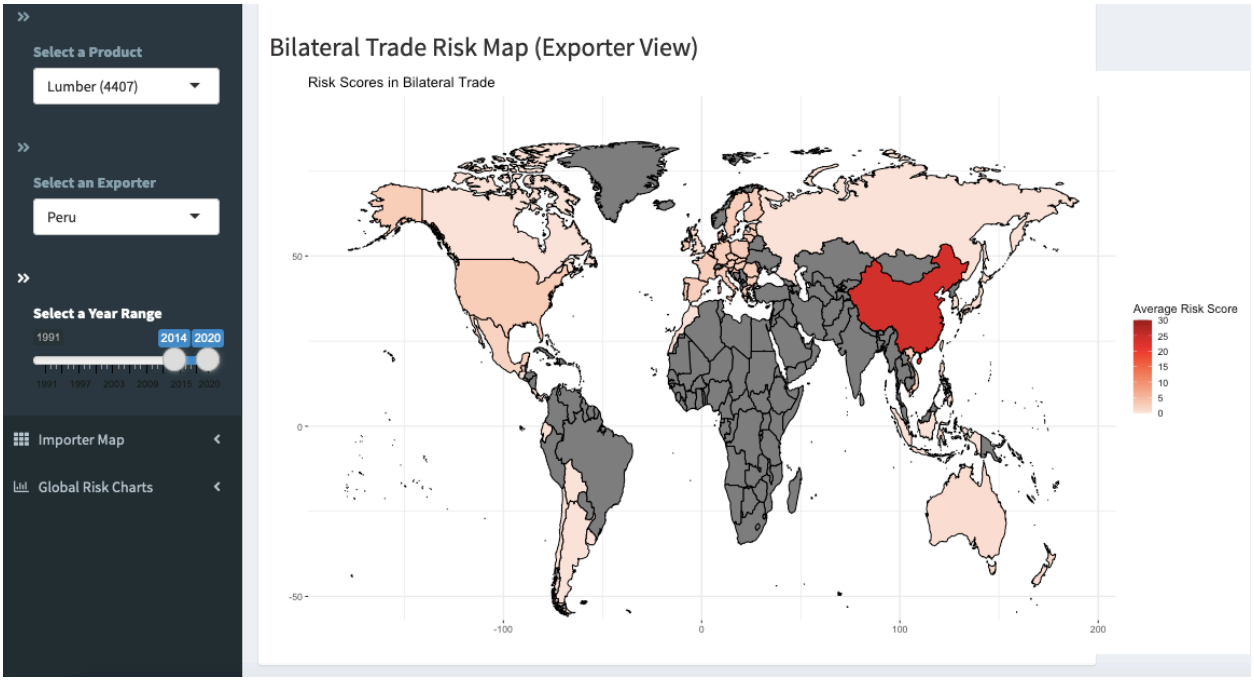


**Figure 8.** Exports of lumber from Peru to its trade partners. China shows as being high risk but less so than the risk associated with logs.

Exports of Peruvian plywood show very high risk in trade with Mexico while low risk is shown for all other trade partners.

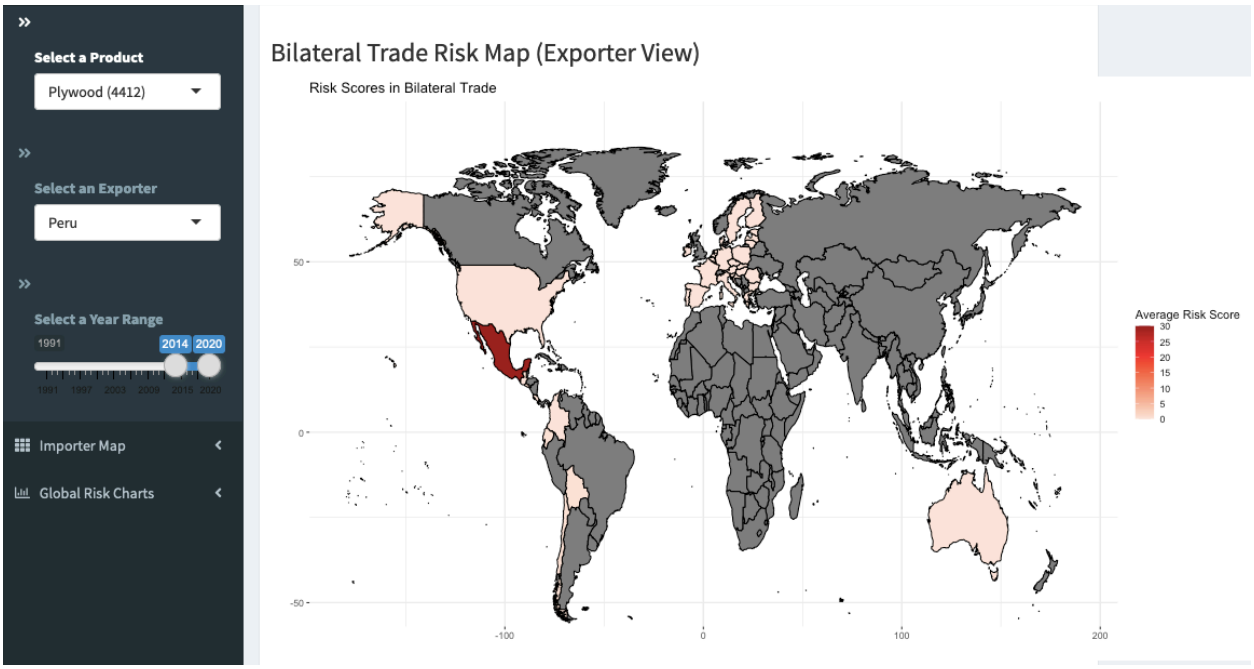


**Figure 9.** Exports of plywood from Peru to its trade partners. Trade with Mexico is indicated as being very high risk.

Insufficient enforcement of environmental regulations and corruption in Peru have led to issues of illegal loggers extending roads and encroaching on indigenous land to cut down trees (Ionova, 2021). Other methods of making illegal timber appear to be legal are often being used, with loggers frequently adjusting their methods to avoid detection. Permits that allow land to be switched between agricultural, forest and private use are an issue for tracing legality and loggers often declare false locations in a section of forest while harvesting from another (Praeli, 2019). Adding in Peru's tax refund that is based on the value of the export shipment exacerbates the issues of illegality (Pardo-Herrera, 2021).

Pardo-Herrera's study on the Peruvian timber trade and the use of discrepancy analysis highlighted several red flags in Peru's trade patterns, many of which were reflected in the maps generated by this study. For both logs and lumber, China appeared as having high risk trade with Peru. Pardo-Herrera states that regardless of the type of timber product reported by Peru, China had reported all imports as lumber or chipped wood, which explains why the discrepancy and

resulting risk score for logs was higher than that of lumber. The value of Peru's exports was also stated as being significantly higher than the values reported by China, likely to take advantage of Peru's export incentives, which also fits with the resulting risk scores for logs and lumber exports to China. In the trade with Mexico, Pardo-Herrera found that there was a large amount of discrepancy, especially with plywood and laminated wood because they are more difficult to accurately identify and therefore easier to mis-value without getting caught, allowing traders to avoid Mexico's import taxes. These findings match the results of the generated map for Peruvian plywood as well, which placed trade with Mexico at very high risk.

Other findings by Pardo-Herrera included discrepancy with the United States for total timber exports, however the maps for this study only showed some slight elevated risk for lumber and very little for logs and plywood. This is likely because the findings from Pardo-Herrera's study concerning the US mention total timber exports instead of a specific product type which would include timber products not currently included in this study. This study also currently lacks data from the Dominican Republic and cannot yet evaluate its risk of trade with Peru, another problematic trade flow pinpointed by Pardo-Herrera.

## Chapter 7. Highest risk trade flows

The highest risk trade flows for each product type were determined based on the trade data from 2014 to 2020 to give a more accurate representation of data trends after the implementation of relevant international regulations like FLEGT and the EU Timber Regulations. When the discrepancy scores for each product type are distributed normally, trade flows that fall within the range of -0.5 and 0.5 standard deviations are removed to not be considered for designation as highest risk. This was done to prevent a trade flow with low

discrepancy from being chosen as high risk based on its high market share alone (since Risk = Discrepancy * Market Share). Any of the resulting high risk trade flows would need to have high discrepancy and high market share to be included in the high-risk charts. For each product, three charts are displayed in the graphic; a vertical bar chart at the top that shows the risk score associated with each trade flow, a plot on the bottom left that shows the discrepancy in the trade flows, and another bar chart on the bottom right that shows the portion of the global market share that trade flow occupies. In this way, these graphics show each piece of the equation Risk = Discrepancy * Market Share. The Risk and Discrepancy graphics are color coded with red or green, with red showing that the importer reported the higher values and green showing that the exporter reported higher values. Market Share is always shown in red since who reported the greater value is irrelevant. Rankings of the top high risk trade flows by products show Hong Kong to China (with New Zealand to Hong Kong as second), Ghana to India, and China to the EU as having the highest risk of illegality for logs, lumber, and plywood, respectively. Since discrepancy analysis is a rough estimate and discrepancy can be caused by factors other than illegal trade, a case study analysis was done for each of these to determine if the risk score is likely to be caused by illegal trade and if not, what the cause might be.

***Case Study 1: New Zealand to Hong Kong to China***

The risk score in this case seems to be caused by reporting issues related to re-exporting through Hong Kong. Given New Zealand's strong forest policy and China's tendency of reporting the goods transported through Hong Kong as being from the country of origin, it seems that the risk score is being inflated by misreporting unrelated to illegal trade. Since logs from New Zealand account for about half of the logs going through Hong Kong to China, this trade flow would not be the highest risk for illegal trade of logs, however this does not discount the possibility of illegal log trade involving a different country of origin.

Trade flows were ranked by their calculated risk score for each of the three product types with the 10 highest risk trade flows for each product being displayed in the risk charts section of the app. For trade flows of logs, Hong Kong to China ranked as the highest risk having a discrepancy of 72.7% with Hong Kong reporting higher values than China. In terms of market share, trade from Hong Kong to China shows as being 0.59% of the total global log export market. Notably the second highest risk trade flow also involves Hong Kong, with exports coming from New Zealand. The New Zealand to Hong Kong trade flow had a 100% discrepancy with New Zealand reporting values and Hong Kong reporting none, while the percentage of the global market occupied is 0.32%.

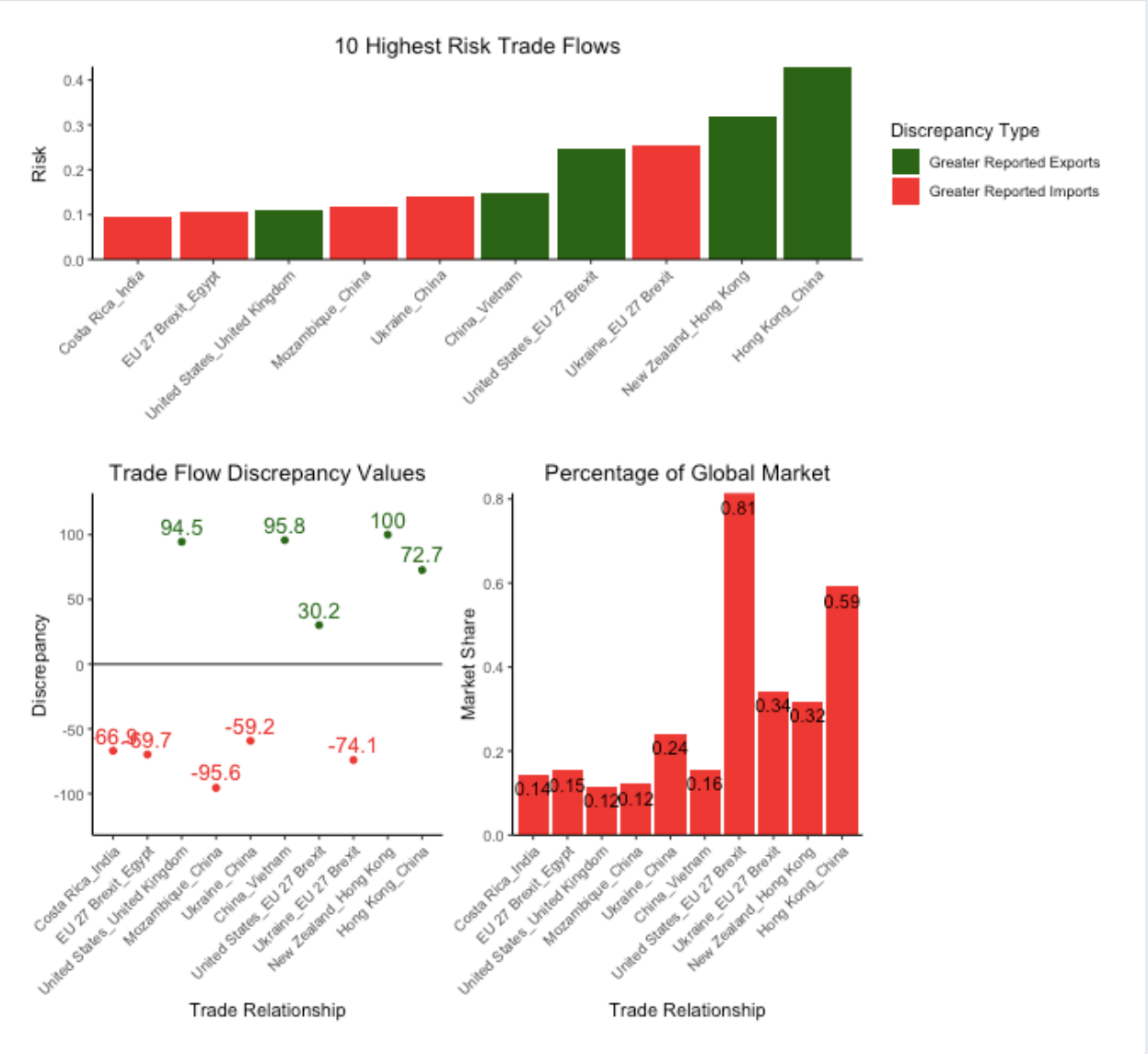


**Figure 10.** Highest risk trade flows for logs (4403)

This research primarily focuses on bilateral trade, but because Hong Kong shows as being both the exporter in the highest risk trade flow and the importer of the second highest risk trade flow, both are analyzed to provide the full context and evaluate if the risk scores from these two trade flows are related. This case analyzes the relevant factors for New Zealand, Hong Kong, and China. Relevant factors are considered for both trade flows to determine if the high-risk score truly reflects the possibility of illegal trade.

*China*

China covers one of the largest ranges of biodiversity in the world, containing around 10% of all species on Earth, many of which are endemic to China (World Bank, 2001). Unfortunately, rapid economic growth and institutional restraints have contributed to deterioration of its biodiversity and ecosystem services, especially with the degradation of its natural forests (World Bank, 2001; Liu and Diamond, 2005). However, China has also made political commitments to international conservation efforts as well as laws and regulations for domestic species and habitats, particularly in its forest protection policies. Prior to the late 1990s when China initially implemented its domestic forest protection policies, the weak forest regulations and enforcement allowed for high rates of deforestation which contributed to soil erosion and increased flooding (Zhang et al., 2000). Deforestation on the steep slopes of the Yangtze River's upper region culminated in a devastating flood in 1998 that caused many casualties and the loss of housing for many more. This flood prompted the creation of the National Forest Protection Program (NFPP) and the Slope Land Conversion Program (SLCP) in 1999 (Zong and Chen, 2000). The NFPP banned harvesting in nearly half a million square kilometers of forestland to reduce commercial logging by 62% (Ren, 2015). The SLCP is an afforestation program that provided payment to rural farmland owners in the upstream region of the Yangtze if they reforested and maintained their land. This was meant to help prevent the soil erosion and flooding and to provide ecosystem services to populations living downstream (Gutierrez Rodriguez, 2016). This helped with the soil erosion and flooding but wouldn't help much with other ecosystem benefits and biodiversity, as most of the land was reforested as a monoculture and not a diverse habitat. In 2017, the NFPP was extended with the Domestic

Natural Forest Logging Ban that prohibited all logging in natural Chinese forests. Domestically harvested timber could only come from plantations (Forest Trends, 2016). Another amendment to the National Forest Law came in 2020 with the addition of article 65 that bans the purchase, processing, or transport of any timber known to be from an illegal source. However, details on how exactly this would be implemented and enforced are unclear, even after a version of the article was released to the public in 2022 (Forest Legality Initiative, 2022).

**Summary of Relevant Policies**

- National Forest Protection Program (1999) – restricted available areas for harvest to reduce commercial logging by 62%
- Slope Land Conversion Program (1999) – provided payment to rural farmers in upper river regions to convert farmland to forest
- Domestic Natural Forest Logging Ban (2017) – outright ban on harvesting from domestic natural forests
- National Forest Law Amendment Article 65 (2020) – bans the purchase, processing or transport of timber known to be from an illegal source

The habitat degradation resulting from the demands of China's rapid economic growth and expanding population is of serious concern for maintaining the high biodiversity and preventing natural disaster like the Yangtze flood in 1998. Chinese conservation efforts are well known internationally, particularly for its charismatic species like the Giant Panda, but overall, China has 212 types of natural forests which include around 200 known plant species that have gone extinct, 15-20% of the remaining plant species in these forests are endangered, 233 vertebrate species are close to extinction and 61% of all species in China have been affected by habitat loss

(Ren, 2015). China's conservation laws are often "vague and ambiguous, reading more like policy statements rather than directives" (Yu and Czarnezki, 2013). This ambiguity makes implementation and enforcement difficult and therefore decreases their effectiveness. The recent addition of article 65 to the National Forest Law in 2020 is an example of the ambiguity in conservation laws. At a surface level this law is meant to prevent any handling of timber known to be from illegal sources both domestic and foreign. However, the law does not give any guidelines for due diligence on the trader's behalf, nor does it indicate how the law will be implemented. If knowing that a product came from an illegal source is what makes the trade illegal and there are no requirements that make a trader check if it comes from an illegal source, then the obvious loophole is to know as little about the source as possible and claim ignorance to avoid the punishment (which is also ambiguous). The more clear and strict domestic policies for forestry add more protection to China's domestic forests, but the vagueness of the laws that would in theory handle illegal forest products from outside China afford very little protection to international forests. The combination of strong domestic forest protections with minimal international protections encourages traders to source any illegally obtained product from outside of the country and essentially outsource deforestation and other forest biodiversity and habitat issues.

The ban on logging in natural forests means that domestically China can only produce timber from plantations, which is not enough to meet the massive demand. Therefore, China greatly relies on imports of timber products with New Zealand being its largest supplier of softwood logs. In relation to Hong Kong, China treats it as a major trade port for goods entering and leaving from mainland China, so these imports are likely going through Hong Kong on the way to China. In 2018, China imposed retaliatory tariffs on imports of wood from the United

States because of the 25% tariffs the US placed on Chinese goods entering the US (Greene, 2019). As of late 2022, the tariffs on US produced wood were still in place and this would clearly encourage traders to import from other countries. Also in 2022, Russia implemented a log export ban to encourage value-added production in country (Ekstrom, 2022) and China began plans to reduce tariffs of wood and paper from New Zealand to 0% over the next ten years as part of the expansion of its free trade agreement (Reuters, 2022). Since the data considered in this study currently goes to 2020, the changes with Russia and New Zealand would not yet be reflected in the data but are important considerations in the assessment of data from this study. The decrease in US timber because of the tariffs and the removal of Russian logs eliminates two sources of timber in recent years, combined with decreasing tariffs on New Zealand wood and paper suggests that China may increase their sourcing of wood from New Zealand in the future.

*Hong Kong*

Most of Hong Kong is an urban environment with limited forest resources. The hillsides around Hong Kong are highly degraded and historically have had replanting efforts since the 1870's, making it one of the earliest examples of plantation forestry in the tropics. The purpose of the plantation efforts has varied over time, with early efforts in the 19$^{th}$ century being for purely aesthetic purposes, it later shifted to prevention of soil erosion and protection of watersheds throughout the 20$^{th}$ century and finally fully focused on ecological restoration in the 21$^{st}$ century. Hong Kong's natural forests are thought to have been extensively clearcut during the British colonial period and then later replanted to make the hillsides look more attractive. The forests were again destroyed in World War II when they were used up for timber and fuel. Hong Kong didn't have a forestry policy with conservation in mind until 1965 (Nichol and Abbas,

2021). With its extensive history of deforestation, Hong Kong has very little of its own forest resources left and relies heavily on imports for timber and other forest products.

With its extremely limited forest resources, it's unlikely that there is much illegal timber originating from Hong Kong itself and domestically harvested timber is not much of a conservation concern. Many of the conservation issues in Hong Kong are more related to aquatic wildlife and not forestry but Hong Kong does have a registry for tracking protected trees. Trees protected in this registry include any tree that meets any of the following conditions: larger than a meter in diameter at chest height, more than 25 meters in height, has a canopy larger than 25 meters in width, is a rare or protected species, is over 100 years old, is of historical or cultural significance, or is of outstanding form (GovHK, 2023). Overall, this registry has only included around 500 trees since 2004, most of which do not fall into the protected species category, further suggesting that illegal harvesting is unlikely to be occurring in Hong Kong. Any illegal trade of timber or other forest products in Hong Kong would be entering or passing through from somewhere else.

Economically, Hong Kong is a free trade port with virtually no barriers on trade. No tariffs are imposed on either imports or exports, although licensing for certain goods is required in accordance with the many international trade organizations and trade partner countries that Hong Kong is involved with (TID: Hong Kong's Trade Policy, nd). As a free trade port, Hong Kong acts as a major trade link between China and its trade partners.

*New Zealand*

New Zealand is included in this case study assessment since it's likely that it is a factor in the large risk score between Hong Kong and China and because of its involvement in the second

highest risk score for logs. New Zealand forestry exports are on average worth an estimated $6 billion annually, being its third largest export industry behind meat and dairy and providing around 1.6% of the national GDP (Ministry of Primary Industries, 2022). Export partners for timber mainly include China, Australia, Korea, and Japan. Of these export partners, timber exports to China greatly exceeds exports to other destinations. Radiata pine is the main species exported, accounting for 90% of the total timber traded, followed by Douglas fir (6%) and other fast-growing species like eucalyptus.

Policies governing the trade of New Zealand's forest products started relatively early with the Forests Act of 1949 which stipulates that harvesting, milling, or exporting any privately owned existing native or regenerating forests must be approved by the Forest Service to ensure that it is done so sustainably. The majority (~80%) of the natural forests are owned by the government are for public use or conservation, while most of the privately owned forests are plantation forests (Ministry of Primary Industries, 2022). The Resource Management Act of 1991 is the central legislation on environmental resources and their sustainable usage, with a council that sets standards and regulations pertaining to forestry and forest products. Another part of this act, called the National Environmental Standards for Plantation Forestry, details the regulations on location, species and if monitoring is required on any planted forests greater than one hectare and are used for commercial or harvesting purposes. There's also the Emissions Trading Scheme for Forestry that states the requirements and obligations of forest landowners to earn carbon credits for forest management (Ministry of Primary Industries, 2022).

## Summary of Relevant Policies

- Forests Act (1949) – Harvesting, milling, or exporting from privately owned natural or regenerating natural forests must be approved by the Forest Service
- Resources Management Act (1991) – central legislation on environmental resources and sustainable management
- National Environmental Standards for Plantation Forestry (1991) – regulates location, species, and monitoring of plantation forest larger than one hectare
- Emissions Trading Scheme for Forestry – sets requirements and obligations of forest landowners to receive carbon credits

Urban expansion and climate change are identified as the primary conservation issues for New Zealand, both of which leading to changes in vegetation the contribute to soil and water quality degradation (Stats NZ, 2019). Much like China, much of the biodiversity of New Zealand is unique to this region. 80% of the plant species are endemic and around 10-15% of the land area is covered by native flora. For forests, this mainly includes beech forests, wetland forests and podocarp-hardwood forests (New Zealand Department of Conservation, 2022). Since New Zealand forestry laws strictly regulate private land use to protect native species and most natural forests are owned by the government and are for public use or conservation, nearly all timber exports from New Zealand are plantation grown radiata pine.

New Zealand's small domestic market makes it especially reliant on international trade and more susceptible to fluctuations in the international market, which has led to it devoting much of its diplomatic effort towards pursuing free trade agreements and its policy making efforts geared towards international trade. Politicians since the 1980s have tended to place trade as the country's primary foreign policy concern (Kollner, 2021). With the Trans-Pacific Partnership,

the New Zealand government expects the GDP to increase by about $2.7 billion annually as more reductions on non-tariff trade measures are attained and go into full effect (Maplesden and Horgan, 2016). Despite the goals of trade expansion and greater GDP, increasing social and environmental considerations, like increased Māori ownership of forest land and furthering the implementation of emissions trading schemes, have led to minimal expansion of its forest log production capability (Chang and Gaston, 2016). China has been New Zealand's primary trade partner for timber exports with which they've had a free trade agreement since 2008. Overall trade with China has nearly quadrupled (as of 2021) since the signing of the FTA. An update to the FTA was signed in 2022 that further reduces tariffs not previously included, particularly wood and paper products, and reduces compliance requirements for New Zealand exporters that were adding cost or limiting access to Chinese markets (New Zealand Affairs and Trade, 2022).

*Hong Kong to China Trade*

Hong Kong to China shows as the highest risk trade flow for logs. The log trade flow from Hong Kong to China has a positive discrepancy of 72.2%, meaning Hong Kong is reporting more exports than China is reporting as imported. This trade flow has a global market share of 0.59%. Trade involving Hong Kong and China is often a source of discrepancy due to the complex relationship between the two regions. Hong Kong, a former British territory, was reunified with China in 1997, but has its own separate customs, is an independent member of the World Trade Organization and reports its own trade information to international organizations (Feenstra et al., 1999). Issues with trade data analysis involving Hong Kong and China have been pointed out by other research, and mismatches in data have been attributed to Hong Kong's role as either a re-exporter from China to its trade partners or as a main port to the Chinese mainland.

Research by Ferrantino et al. that focused on the trade between China, Hong Kong and the United States shows that since the late 1990's the reported imports by the US from Hong Kong or China exceed the reported exports by China and Hong Kong to the US. By focusing on trade that did not pass through Hong Kong on its way to the US, they showed that the discrepancy was not always attributed to transshipment error as was often assumed. They found that nearly two-thirds of the discrepancy was from under-reporting of exports occurring at the Chinese border to avoid paying value-added tax. They also discovered evidence of tariff evasion at the US border and indirect evidence of transfer pricing and evasion of Chinese capital controls. The results of the research by Ferrantino et al. show that in the case of the trade flow from China to the US, Hong Kong transshipment was often incorrectly assumed to be the cause of the discrepancy which concealed illegal causes of discrepancy like tax evasion. Ferrantino et al.'s research focused on the trade flows for products of multiple industries leaving China, whereas this research is concerned with the trade flow of logs entering China. Despite the obvious difference, Ferrantino et al.'s research presents important considerations related to Hong Kong transshipment issues.

To look for misreporting between China and Hong Kong, other studies have also intentionally ignored the statistics involving Hong Kong as a middleman and solely analyzed the direct trade flows. Fung et al. did this as well and discovered that there was a very large amount of discrepancy between Chinese statistics and those of Hong Kong. They suggest that the discrepancy found in their research indicates a consistent one-sided issue with Chinese statistics and was not due to simple statistical error. They suggest that if the discrepancy stemmed solely from statistical error, it would not be as large or as one-sided. Fung et al. also found evidence of round-tripping, where goods were moved from mainland China to Hong Kong and then back to

mainland China to be reintroduced as foreign investment. Results suggested intentional misreporting to evade import taxes as well.

Other factors possibly influencing the trade involving both China and Hong Kong include value-added and shipment cost adjustments as goods pass through Hong Kong. Feenstra et al. were able to reduce large trade discrepancies in trade deficits reported by both China and the US by considering the data from Chinese, Hong Kong, and US sources. Through comparisons of statistics from Chinese sources and statistics from Hong Kong they were able to estimate and adjust for the value-added in Hong Kong more precisely, enabling for a more accurate measure of China-US trade in both directions. Schindler and Beckett adjusted shipment costs so that both imports and exports were considered on a free on board (f.o.b.) basis. This is normally how exports are reported but imports are typically reported as cost, insurance, and freight (c.i.f.), which include the additional expenses from insurance and freight. Adjusting both imports and exports to be f.o.b. would put both imports and exports at equal values if there aren't any other sources of discrepancy. In the case of trade to or from China and Hong Kong, they assumed this adjustment was reasonable because the distance with the trade partner and the mode of transportation to or from either China or Hong Kong would be the same. With this method they found that at the time of study, much of the discrepancy in many of these trade flows was reduced. Schindler and Beckett's research also showed that Hong Kong's role as an intermediary often made reporting accurately difficult and often lead to an increase in unintentional misreporting. The origin of the goods being transshipped through Hong Kong would often be reported correctly by the importing country, but exporters were frequently unsure if the goods being sent to Hong Kong would remain there or be re-exported.

An OECD working paper on statistical issues with international bilateral trade focused on re-exports as a central issue for analysis and data-tracking, with Hong Kong given as a key example. It also points out that approximately 90% of trade to or from Hong Kong consists of re-exported goods involving China (Guo et al., 2009). Despite a large portion of China's trade with the world passing through Hong Kong, it is frequently not reflected in the trade statistics of China or some of its trade partners. The Global Trade Analysis Project (GTAP) has tried to address issues with trade statistics stemming from re-exports through Hong Kong as well by creating a mathematical programming model that estimates re-export markup and reconciles the trade statistics of China, Hong Kong, and the United States with some degree of success (Wang et al., 2006).

*New Zealand to Hong Kong Trade*

While Hong Kong to China received the highest risk score for logs, the second highest is New Zealand to Hong Kong. China is New Zealand's largest trade partner for the export of logs, with about 70% of all pine log exports going to China as their ultimate destination (Armstrong, 2014). The trade flow from New Zealand to Hong Kong has a 100% positive discrepancy, meaning Hong Kong is reporting none of the logs that New Zealand reports as exporting to Hong Kong. This trade flow has 0.32% of the global market for the log trade. Since China is New Zealand's largest consumer of pine logs and based on the 100% discrepancy value between Hong Kong and New Zealand, it's likely that this is another situation where Hong Kong acting as a re-exporter is a key issue. New Zealand is likely reporting its log exports as going to Hong Kong since the shipments stop there before going to mainland China. Factors like shipment cost and shipment time lag could influence trade discrepancy between New Zealand and Hong Kong, but

with a 100% discrepancy these factors are seemingly irrelevant as all the discrepancy is currently coming from Hong Kong not reporting any of the shipments from New Zealand.

*Assessment*

Given that Hong Kong re-exports are a frequently occurring issue for trade data analysis and that New Zealand is known to send most of its logs to China, it's almost certain that these two risk scores are related. Hong Kong doesn't report receiving any of the logs because they are being re-exported to China, but then Hong Kong reports the logs as exports to mainland China. When the logs are received by China, not all of them are reported as being imported from Hong Kong if they are being reported. China could also be reporting them as being received directly from New Zealand. This pattern is in line with the results of Fung et al.'s research that suggest that there is a large, one-sided discrepancy between China and Hong Kong trade flows. It also matches the findings of Schindler and Beckett's research in that exporters in New Zealand seem to not know what shipments aren't remaining in Hong Kong, while China is reporting some of the shipments as coming from the country of origin. Looking at the trade data reported as going directly from New Zealand to China gives an average discrepancy of -17.8% from 2014 to 2020, which shows that China is reporting more logs received from New Zealand than New Zealand reported sending. This overreporting by China amounts to an annual average of around $330 million in value. The value associated with the 72.7% average discrepancy between Hong Kong and China would have an annual average value of around $57 million, while the 100% discrepancy between New Zealand and Hong Kong would amount to an annual average of $30.7 million. Therefore, it's entirely possible that the value of logs that weren't reported by China as being from Hong Kong could have been reported as being directly received from New Zealand.

A comparison of the global market shares of New Zealand to Hong Kong and Hong Kong to China would show that the entirety of the log exports from New Zealand to Hong Kong (0.32% global market share) could contribute to over half of the logs shipped between Hong Kong and China (0.59% global market share). Assuming that the entirety of the current discrepancy between New Zealand and Hong Kong is caused by misreporting issues related to transshipment, the risk score for logs between Hong Kong and China would be lowered if it were disregarded. Given the many notable examples of trade discrepancy issues involving Hong Kong transshipment and the strict forestry laws in New Zealand, this doesn't seem to be the result of illegal trade. However, this does not discount the possibility of illegal log trade between Hong Kong and China from a different country of origin, it simply shows that the risk score for the Hong Kong to China trade flow of logs seems to be inflated by the transshipment of logs from New Zealand. To say for certain what proportion of the risk for the trade of logs from Hong Kong to China is caused by this re-exporting issue with New Zealand and what proportion of the risk is due to actual illegal practices like the ones found by Ferrantino et al. and Fung et al. would require further research, but this data suggests that in this case much of the high risk score between Hong Kong to China and New Zealand to Hong Kong is the result of transshipment error.

***Case Study 2: Ghana to India***

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|---|
| Ghana has a log export ban with exception for certain plantation species which incentivizes exporters to report exporting lumber. India has low log import tariffs which encourage importers to report importing logs. Data for logs and lumber show high probability of misreporting from each side and the risk of illegal trade is high. |

In trade flows for lumber, Ghana to India ranks as the highest risk for illegality. This trade flow is bilateral and doesn't have the complications of re-exports like the highest risk score for logs. There is a 95.1% discrepancy with Ghana reporting the greater values, and trade from Ghana to India accounts for 0.23% of the global lumber export market.

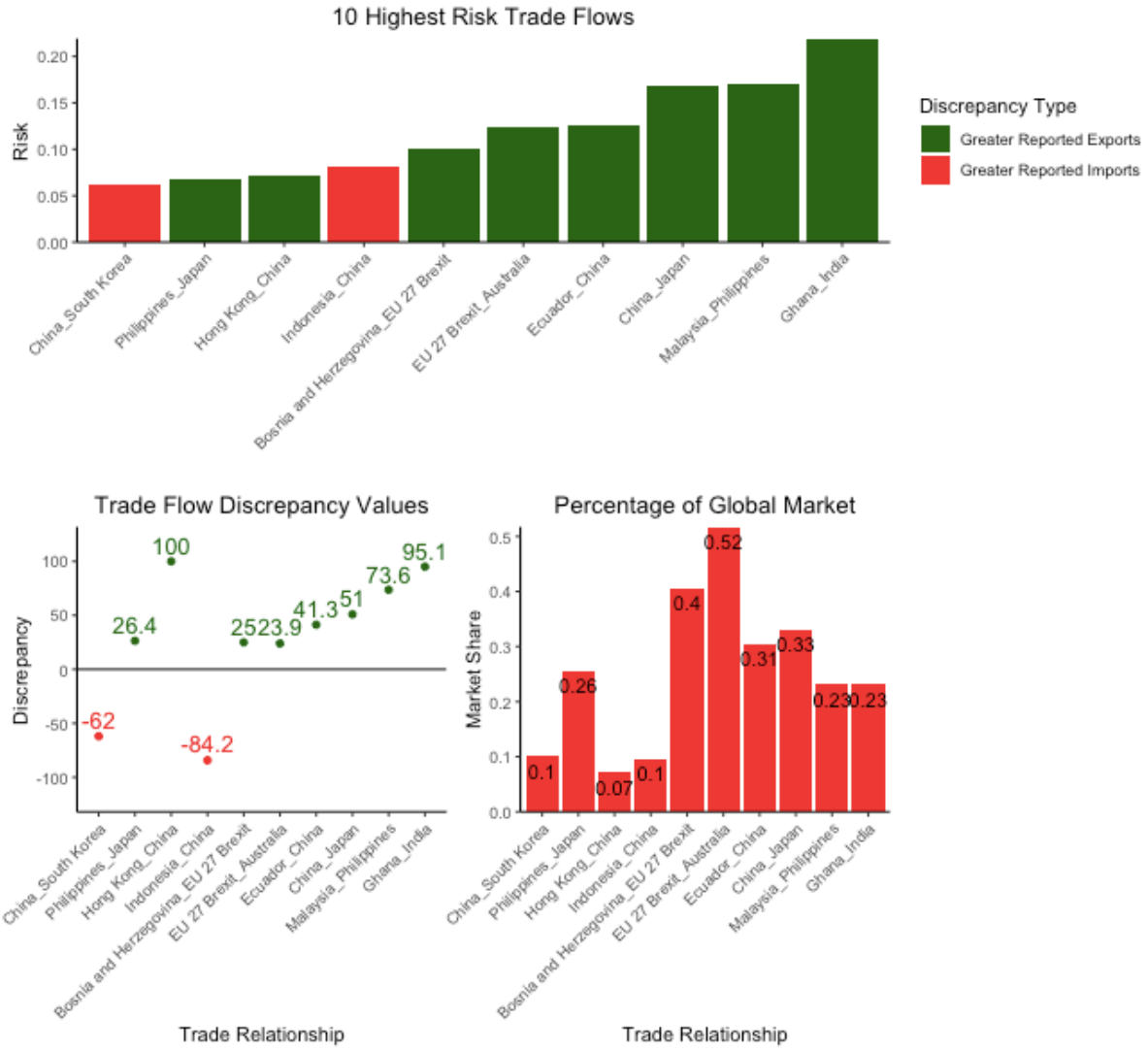


**Figure 11.** Highest risk trade flows for lumber

*Ghana*

Ghana has 7.9 million hectares of forested land, covering a total of 35% of the country's land area. Out of the forested land, 7.6 million hectares are primary or naturally regenerating

forest while 297,000 hectares are plantation forest (FAO, 2020). 10.2% of the land area (2.46 million hectares) is tropical forest (referred to as High Forests) in the southwestern or central parts of the country, while the rest of the forested land is savannah vegetation or buffer zones between the High Forests and the savannah. The buffer forests are rapidly transitioning to savannah due to several factors, including over-exploitation (Convention of Biological Diversity, 2022). About 34% of the forests are in the southern and central High Forest zones while the other 64% is in the savannah and buffer zones in the northern part of the country. 2.6 million hectares are on protected reserve land, 1.6 million hectares of which are of the High Forest type. On the reserve lands, 715,000 hectares are used for natural timber production while the rest is protected or under plantation development. Outside of the reserves, 500,000 hectares of unreserved natural forest and two million hectares of cropland also produce timber. Ghana's Forestry Commission handles the management of forest resources and timber harvesting on reserve lands, but for non-reserve lands their power is limited to regulation (Timber Trade Portal, 2023).

Ghana's first forestry law was prior to World War I and was simply a clause that aimed to preserve sufficient forest land in the High Forest zone to maintain water quality and climate conditions, and prevent soil erosion, all of which are factors affecting the growth of cocoa, cola and other crops that were essential to the Ghana's prosperity at the time. By 1920 a voluntary process tried to convince native Chiefs to set aside some of their land to form reserves, but many felt this was an attempt by the colonial government to take their land and refused. By 1927 the process was determined to be too slow, and an ordinance was passed that made setting aside land for reserves compulsory. By 1948 the first forest policy was created that provided management for forest reserves and scientific research into the suitable use of forest resources for the newly formed timber industry. The colonial government again continued with forced reservation of

land which led to local communities rapidly converting their forests to farmland so that it wouldn't be taken. This forest law stayed in effect past the end of the colonial period, which allowed for unchecked harvesting outside of reserve lands without replacement. Reviews for a new policy began in the 1980s amid deforestation concerns and a new forest law was adopted in 1994. The new forest law provided incentives for responsible use of forest resources and encouraging a shift in the market of producing large quantities of low value raw material to smaller quantities of more valuable value-added products (K. Oduro et al., 2011).

**Summary of Relevant Policies**

- Ghana Forest Policy 1994 – Incentivized responsible forest use and encouraged a shift from exports of raw material to value added products. Exports of logs, with some exceptions, were banned.
- Timber Resources Management Act 1997 - No one can harvest timber from any land unless they hold timber rights in the form of a timber utilization contract. Amended in 2002 to add max limitations on area and duration granted by timber rights, incentives for those that invest in forestry and wildlife conservation and disqualification of rights for involvement in illegal trade (FAO, 2022).
- National Land Policy 1999 – The first complete land policy in Ghana's history, framework identifies all relevant stakeholders to be a part of any decision-making process to rectify past issues associated with non-equitable land management. Also states that no primary forest land or plantation can be cleared to establish mining operations (ClientEarth, 2019).

- Forestry Commission Act 1999 – Established the regulatory body that manages reserve forests and assists private landowners with implementing forestry and wildlife protection laws. Divided into 4 divisions: Forest Services, Forest Products, Timber Export Development, and Wildlife (FAO, 2022).
- Timber Resource Management and Legality Licensing Regulations 2017 – Reforms the Timber Resources Management Act to regulate the identification of land that can be used for timber rights, the terms for small- and large-scale timber rights, other timber sources, and provide a legality licensing scheme. The further development of timber legality is part of the voluntary partnership agreement (VPA) between Ghana and the EU. Furthermore, to combat corruption the Timber Validation Committee is established to monitor the division responsible for giving and verifying licenses and ensuring it is done in a transparent way, create measures that ensure that monitoring these activities is not interfered with, and settle complaints (FAO, 2022).

Ghana is home to roughly 5000 species of flora and fauna with many of them being endemic to the High Forest regions. There is a notably high level of biodiversity and endemism among Ghana's species, especially its birds and butterfly species, but a general trend of declining biodiversity and species numbers has been especially prevalent in over-utilized forest areas. Ghana's biodiversity is threatened by habitat degradation caused by pollution, misuse of chemicals and bush burning techniques, climate change, wildfires, over-exploitation of resources, and land conversion to farmland. Over-exploitation includes over-harvesting of natural resource species like bananas, cocoa, yams, and certain mangrove species and excessive cutting of trees in already stressed areas for use as timber or an energy source like charcoal or

firewood. Land use conversions typically involve changing large areas of forest to farmland or monoculture plantations of tropical hardwoods. Over-exploitation and land use conversion has been accelerating as soil quality declines on existing farmland and food insecurity and poverty increases (Convention on Biological Diversity, 2022).

Multiple native tree species used for timber have CITES classifications or are listed by the International Union for Conservation of Nature (IUCN) as vulnerable, threatened, or endangered. African Teak/Afrormosia (*Pericopsis elata*) and African Rosewood/Kosso (*Pterocarpus erinaceus*) are two endangered species with CITES appendix II listings. African Teak is a valuable substitute for Teak that is moderately heavy and durable, often being used for flooring, veneer, and shipbuilding. In Ghana, African Teak is illegal to harvest if it's from a natural forest without a permit and if less than 110 cm in diameter at chest height (Forest Legality Initiative, nd.). African Rosewood is valued for making furniture, and prior to its CITES listing in 2016 was the most traded tropical hardwood due to the high demand for rosewood furniture in China and some other Asian countries. Felling and export bans for African Rosewood in Ghana were implemented after the CITES listing but some studies have suggested that its exploitation and illegal trade have more than doubled in the post-CITES years because of abuse and misapplication of permits, a lack of monitoring and transparency, corruption, and non-compliance (Dumenu, 2019). African Rosewood is of further environmental concern because it's a keystone species in the buffer forests between the High Forest zones and the savannah. It's a nitrogen fixing species and is fire-resistant, helping to prevent the spread of savannah wildfires into the High Forest (CITES, 2016). Ghana has intermittently banned the harvest and export of African Rosewood/Kosso since 2014, with the most recent ban implemented in 2019 having been extended indefinitely in 2021 (Forest Trends, 2021). African Mahogany (*Khaya ivorensis*)

currently has no CITES listing but is endangered because of its slow regeneration rate in the wild. It takes at least 30 years to mature and after that only produces seeds every 3 or 4 years. However, its valued for its high-quality wood and is used as a plantation species. African Mahogany (*Khaya anthotheca*) and Tigerwood (*Lovoa trichiloides*) are among many other native vulnerable species with harvesting restrictions (Forest Legality Initiative, nd.). Plantations grown for timber harvest include a few non-native species like Caribbean Pine (*Pinus caribaea*), Okoume (*Aucoumea klaineana*), and Teak (*Tectona grandis*) as well. Some of the plantation species, like Teak, are exempt from the log export ban (Forest Trends, 2021).

Ghana was one of the first countries to enter into a Voluntary Partnership Agreement (VPA) with the EU in 2009. The VPA serves as a trade agreement between the EU and its trade partners that sets standards for monitoring and ensuring that products are not obtained through illegal trade. After the implementation of these standards, FLEGT licenses are issued to traders sending products to the EU to show importers that they have been sourced legally. Ghana was one of the first countries to enter a VPA with the EU because at the time a large proportion of its timber was being sent to the EU, however in recent years those exports have shifted towards markets in Asia, limiting the power of the VPA to curb illegal harvest and trade of forest products (FAO, 2015). A study by Acheampong and Maryudi conducted village level interviews of farmers, traders, and wood processing workers in three regions of the High Forest zone to ascertain levels of compliance with forestry regulations and motivations for non-compliance. They found that many timber exporters who were at one time primarily exporting to the EU were now focused on less strict markets in Asia, mainly China, India, and Vietnam. 30.7% of the wood exports from Ghana were headed to the EU in 2013 (the onset of EU Timber Regulations) and by 2018 this percentage had dropped to 10.9%. Meanwhile, timber exports from Ghana to Asian countries had

risen from 24.1% to 75.6% in the same period. They also found that there was an increase in overland trade to nearby African countries as well that was not accurately reflected in the reported data. Reasons given as to why trade had decreased with the EU were high levels of perceived corruption in Ghana's Forestry Commission, the difficulty of handling the bureaucratic nature of the EUTR, the cost of going through the EUTR due diligence process (costly verifications that cut into exporter gains), the high quality standards of the EU buyers who want kiln dried wood (air dried wood is usually produced in Ghana), and the species preferences of the Asian market. Not mentioned in the interviews were the quickly increasing demand in the Asian market, which Acheampong and Maryudi also suspected was a likely motivator. Through these interviews they found that in general many involved in exporting timber from Ghana felt that the VPA and the EUTR did not consider the reality of local situations and therefore avoiding it was a legitimate response. Many also felt that the Forestry Commission of Ghana was not morally right in enforcing timber harvest legality when it participated in illegal activity itself, mainly bribery and cooperation with illegal loggers. The difficulty in exporting to the EU was also linked with several timber firms going out of business when they couldn't find sufficient resources that fulfilled all the requirements as well a shift towards supplying domestically instead of exporting (Acheampong and Maryudi, 2020). Finding a new market that earns an exporter more money doesn't necessarily mean that what they are doing is illegal, but those doing illegal trade are likely to follow the same patterns.

*India*

India's first forest policy was adopted in 1894 by the British colonial government and was focused on timber management. However, overharvesting during this time was prevalent,

particularly during both World Wars, resulting in considerable forest degradation. By the time of its independence, the government owned around 40 million hectares of forestland and the post-independence forest policy proposed that 33% of the country should be covered in forest. By the 1970's this area had increased to 76.5 million hectares, but 4.5 million hectares were later lost in the 1980's due to agricultural land conversion and this decrease continued through the 2000's (Forest Policy Reforms in India – Evolution of the Joint Forest Management Approach, 2003). As of 2021, India's forest cover is reported as 80.9 million hectares, which is approximately 24.6% of the geographical area (Ministry of Environment, Forest, and Climate Change, 2021).To meet the goal of 33% forest cover India would need around 108.5 million hectares.

**Summary of Relevant Policies**

- Indian Forest Act 1927 – Defines the procedure to be followed for declaring an area as a reserved forest, protected forest or a village forest (Aggarwal, 2020).
- Wildlife Protection Act 1972 – Created to protect the wildlife species in India from poaching, smuggling, and illegal trade. Amended in 2003 to make punishments stricter (Wildlife Protection Act 1972|National Portal of India, 2021).
- Forest (Conservation) Act 1980 – Restricts the power of authorities to revoke the reserved status of a forest and prohibits the use of forest land for non-forest purposes. Also constitutes a forest conservation advisory committee and provides them regulation making powers ("Forest (Conservation) Act 1980", 2020).
- National Forest Policy 1988 – Revision of previous forest policy to work towards conserving national forests and restoring forest cover.

- Forest Rights Act 2006 – Restores rights over traditional forestland to tribal and marginal communities that were dependent on the forestland for their livelihood (Forest Rights Act, 2012).
- Compensatory Afforestation Funds Act 2016 – Establishes funds under the Central Government and each State gathered from users of forestland for non-forest purposes to be put towards afforestation, regeneration, and protection of forests (compensatory Afforestation Funds Act, 2020).
- Plant Quarantine Order 2003 – Specifies which plants and plant products are allowed to be imported into the country, actions needed for import and the processes that should be taken for plants not specified. Plants and plant products allowed to be imported do not have quantitative restrictions (Sood, 2019).

India has been in the process for years of creating a new national forest policy to replace the previous one from 1988. A draft was revealed to the public in 2016 but was retracted after being criticized for being too weak in forest protection. Another draft was announced in 2018, followed by a revision in 2019, but official implementation has yet to happen. As of the time of this study the forest policy of 1988 is still in effect, but without further update for considerations like climate change and pollution, the forest policy is viewed by some as insufficient (Aggarwal, 2020). The most recent draft of the new forest policy has also been criticized for solely focusing on domestic forests, while noting that timber imports are increasing yet not addressing illegal imports. Chatham House's forest policy assessment rated India's enforcement as weak, with officials sometimes working with limited resources and equipment (Chatham House, 2020). India's forest policy is geared towards protection of its domestic forests while meeting the

demand for timber with imports. Domestically produced wood is harvested from trees that are from areas considered to not be forested, such as plantations or non-forested private land. To match the demands of its rapidly growing population, India heavily relies on imports of wood (Sood, 2019).

India is one of the world's largest hotspots for ecological biodiversity with 8% of the world's wildlife and its wide range of diverse climatic patterns and habitats (Krishnan, 2022). 26.4% of the animal species in India are endemic as are 33% of the plant species. India has a wide range of forest types where many of these species reside, including tropical rainforests in the Andaman Islands, Northeast regions and the Western Ghats, wet deciduous forests in the East, dry deciduous forests in Central and Southern India, thorny forests in the plains and coniferous forests in the Himalayas. India is also home to 16% of the world's total human population, and continues to grow rapidly, putting even greater pressures on these environments (Soni, 2020). Despite being a member of CITES, India is a known hub for the trafficking of wildlife and wildlife derived products (Krishnan, 2022), not only as a source but also as a transit country and a destination. High demand for wildlife derived raw materials like rare woods and ivory combined with porous land borders with China, Myanmar and other Southeast Asian countries, and the increasing use of social media as online marketplaces for wildlife traders all make combatting the issue difficult (Krishnan, 2022). The problem in India with conservation is not so much a lack of appropriate laws but more so a lack of effective communications, implementation, and enforcement. Failures in governance and a lack of political support have also often led to weak punishments for violations in the past, lowering the disincentives for overexploitation and illegal trade ("Illegal Wildlife Trade in India", nd.). With the limited domestically produced supply of timber, India relies on imports to meet much of its demand for

timber and it's the third largest importer of illegal wood behind China and Vietnam. According to a study by the International Union of Forest Research Organization (IUFRO), India accounts for an estimated 10% of the global illegal wood imports (Rathore, 2016).

Aside from the demands from India's massive population, the quickly developing furniture manufacturing industry in India is certainly increasing the demand for timber imports and is likely contributing to the increases in illegal imports. India's furniture manufacturing industry is working towards competing with those of China and Vietnam, with exports of value-added wood products from India having increased by 138% since 2010. Similarly to China, India can't meet its timber demands domestically with its domestic forest protections and essentially outsources deforestation issues to meet its timber demand. Despite efforts to increase domestic forestry production, most of it goes to poor rural populations for use as firewood and cooking (Norman and Canby, 2020). As India expands its furniture manufacturing, it looks to expand exports to markets in the US, EU, Australia, Japan, and Korea, which have regulations prohibiting products made from illegally sourced wood and require verification systems of the entire supply chain. Indian manufacturers and exporters unfamiliar with these types of due diligence systems and would put both themselves and their buyers at risk of legal action. Importers in India are incentivized to import logs (or report they are importing logs) because logs have very low tariffs compared to other value-added wood products. This was done to encourage value-added production in country (Sood, 2019). In recent years many of India's trade partners have implemented log export bans or quotas, forcing them to import more lumber and veneer. Values of total log imports have dropped as values for lumber and veneer have risen, however the value of log imports remain much higher (Norman and Canby, 2020). An inadequate number of sawmills may also be a factor in this (Sood, 2019).

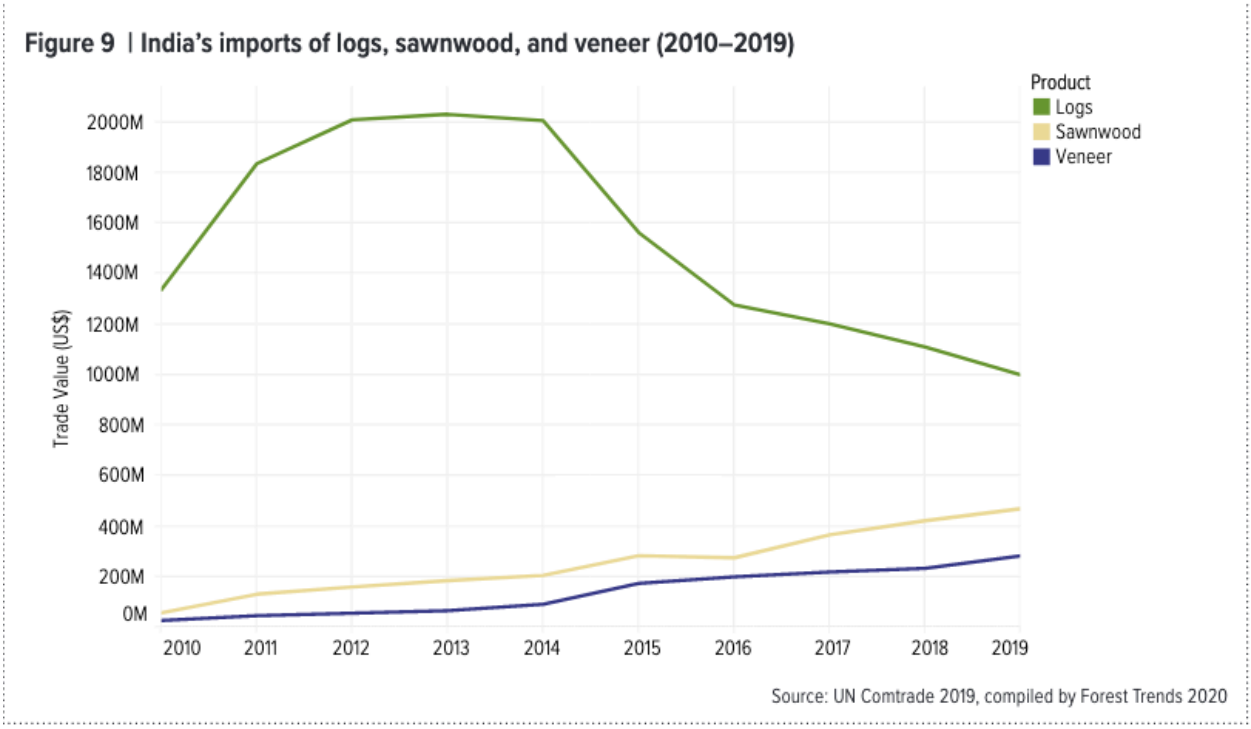


**Figure 12.** Forest Trends, 2020.

*Assessment*

Ghana has a variety of timber that can be sold or are in high demand in Asian markets with a few of them being species that have become a conservation risk due to overharvesting. The shift away from EU markets towards less regulated Asian markets weakens the ability of EU regulations to prevent over-exploitation of tree species and the increasingly high demand due to India's large population, its growing furniture manufacturing industry, and its lack of domestically produced wood makes India and easy and less-regulated market to sell to. Although India is a member country of CITES, its enforcement is weak due to lack of equipment and resources to handle the large volume of imports. With the log export ban in Ghana and the low log import tariffs in India, exporters and importers in this trade flow are both likely to misreport the product type being traded.

**Table 3.** Discrepancy values for logs and lumber in Ghana to India trade.

| Exporter | Importer | Product | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ghana | India | Logs(4403) | -94.9 | -87.6 | 71.4 | -86.4 | -97.6 | -90.3 | -81.3 | -86.2 | -89.8 | -94.7 | -88.6 | -92.8 |
| Ghana | India | Lumber(4407) | 98.9 | 97.6 | 99.5 | 99.1 | 98.8 | 98.6 | 99.7 | 99.9 | 98.2 | 96.4 | 90.3 | 82.4 |

The discrepancy between Ghana and India for logs and lumber are very high (nearly 100% discrepancy in multiple years), with logs typically being negative values indicating India is over-reporting, and lumber being positive values, indicating Ghana is over-reporting. Both patterns make sense when considering the log export ban in Ghana and the low log import tariffs in India. The average annual value of the discrepancy for logs shows India over-reporting by about $35 million, whereas the annual average value of the discrepancy for lumber shows Ghana over-reporting by about $47 million. Misreporting by Indian importers in this scenario would be a financial crime (taking advantage of import tariff rates) while misreporting by Ghanaian exporters could potentially be both financially and environmentally illegal (evading export ban/quotas and/or exporting protected species under the guise of a different product). With the misreporting of product type being so frequent, the trade of both logs and lumber from Ghana to India seem to be at very high risk of having illegal activity.

***Case Study 3: China to the EU/Indonesia to China***

Plywood trade from China to the EU ranked as highest risk, however all forms of trade between China and the EU have shown consistent discrepancy problems related to shipment costs and the use of multiple ports in the process of shipping. The trade flow's massive market further exaggerates the risk score. Indonesia to China ranked as the second highest risk for plywood. Indonesia's history of relying on timber as a source of income combined with its often-contradictory forest policies allow for high risk of illegal trade to China, which lacks policies preventing the import of illegal timber products. The spike in plywood discrepancy after the implementation of Indonesia's legality verification system and the lack of reported exports of logs in the same time frame while China reported log imports from Indonesia suggests frequent misreporting of product type.

For plywood trade flows, China to the EU ranked as the highest risk. This trade flow had a discrepancy of 56% with China reporting the greater values, and trade from China to the EU shows as being 4.45% of the global total plywood export market. However, trade discrepancy between China and the EU is a known and consistent issue in all forms of trade, not just timber products. Prior studies have shown that much of the discrepancy between China and the EU is attributed to re-exports through Hong Kong and other ports and differences between FOB and CIF shipment costs, and accounting for these factors greatly reduces the discrepancy (Jiang, 2019). These discrepancy factors are likely accentuated even further by the huge global market share that this trade flow occupies. With the likelihood that this trade flow's risk score is due to factors other than illegal trade and the complexities of handling data from the EU (since it is comprised of 27 countries), for the purposes of this case study the second highest risk score for the trade of plywood will be analyzed instead. The second highest risk trade flow for plywood in trade from Indonesia to China. On average Indonesia reported values that were 78.8% higher than what was reported by China and the trade flow occupies 2.05% of the global market for plywood.

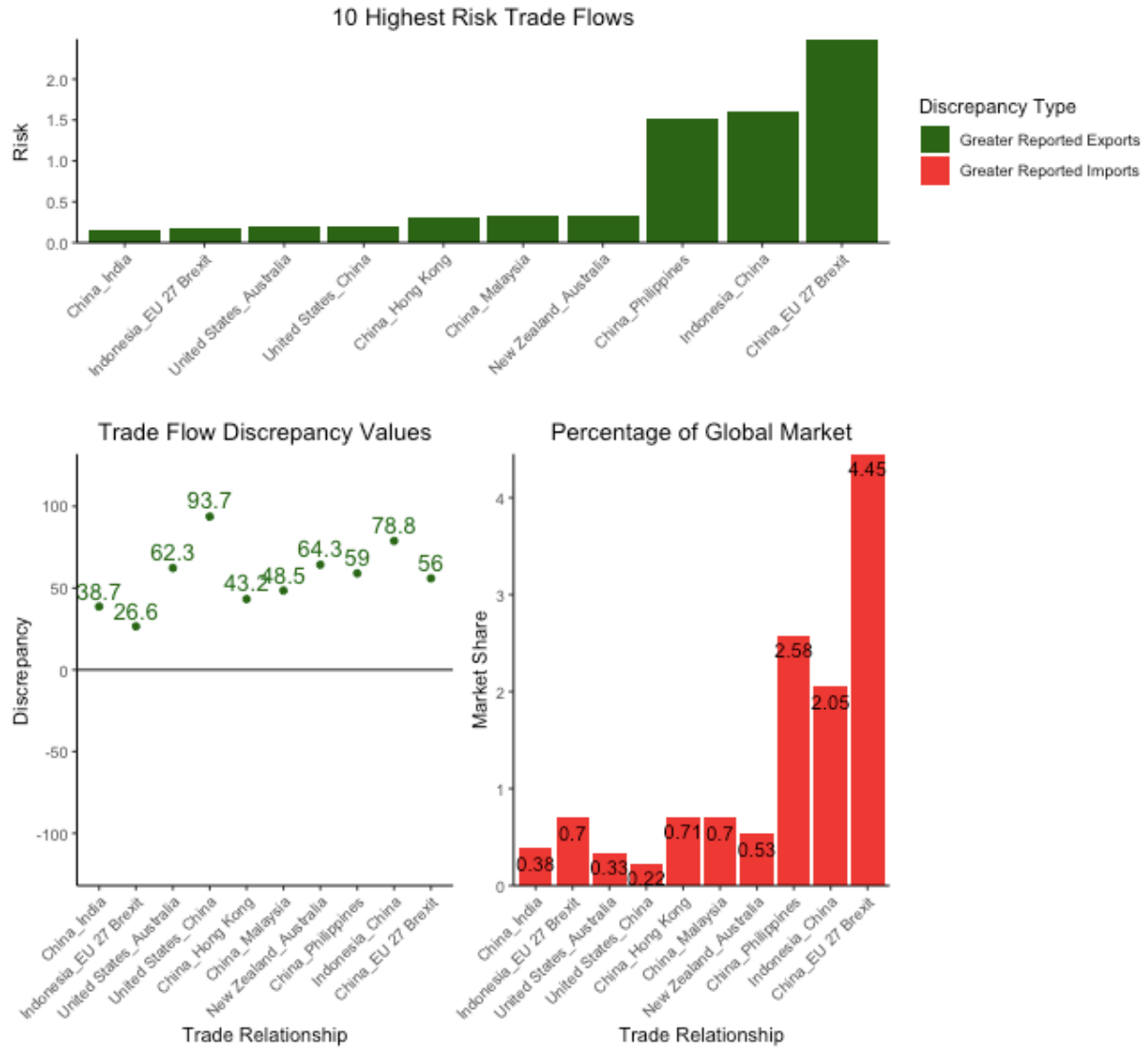


**Figure 13.** Highest risk trade flows for plywood

*China*

The country context, policies, conservation concerns and economic factors related to China and the trade of timber were previously covered in case study 1, the trade of logs from New Zealand to Hong Kong to China. The only relevant addition in the case of trade from Indonesia to China is the signing of a Memorandum of Understanding Concerning Cooperation of Combatting Illegal Trade of Forest Products between the two countries in 2002. However, this

memorandum had no associated regulations or enforcement and is unlikely to have had any sort of significant impact on illegal trade prevention (Stanovsky, 2020).

*Indonesia*

Indonesia has the third largest rainforest biome in the world behind the Amazon and the Congo Basin, with about 91 million hectares of forest. Recent estimates put this forest cover as covering 49.8% of Indonesia's land area, but it was originally thought to have had 99.2% forest cover. Indonesia was mostly forested as late as 1900 when it was colonized by the Netherlands. After this point, high population density in some areas like Java led to intensive domestication and rice paddy cultivation, triggering some deforestation in those areas. Agricultural practices like rice cultivation were the main cause of deforestation during this time as the simple selective cutting practices used to gather timber did not have much of an impact on the natural regeneration of the forests (Tsujino et al., 2016). Forestry laws throughout the Dutch colonial rule and post-World War II were at the local and provincial levels and varied between locations (Stanovsky, 2020). Indonesia declared its independence in 1945 and by 1950 the total forest cover was around 162.3 million hectares (84.9% land area) including regenerating forests and plantations forests used for growing teak, tea, coffee, and rubber. Excluding plantation forests put these numbers at 159 million hectares (83.5% land area). In the 1960s, poverty, hunger and disease was prevalent in the Indonesian population because of severe drought, poor policy decisions and corrupt officials, which led up to the downfall of the first Indonesian president Sukarno and the rise of Suharto, Indonesia's second president in 1967 (Tsujino et al., 2016).

Suharto established national control of forest resources in 1967 and tried to attract foreign investment and increase revenue for national development programs. By 1970, forest

concessions were increasingly used for economic and political patronage, with large scale concession rights being granted to Suharto's family, friends and anyone that could contribute financial or political support, especially among military leaders. Under this system of patronage, forest and harvesting rights were concentrated in the hands of a few people that collected nearly all profits from the international timber boom. Rural communities near the concession operations received no benefit and were often further disadvantaged by the operations (Obidzinski and Kusters, 2015). The large-scale logging operations in the early 1970s initiated the acceleration of forest degradation in Indonesia. Logging companies from neighboring countries like Malaysia were able to get large concessions to convert rainforest into pulp for Japanese paper mills and timber production and export increased rapidly (Tsujino et al., 2016). Initially, small scale operations were allowed, but by 1971 Suharto banned them entirely under the premise that they were wasteful and inefficient, further cementing the control of forest resources into the hands of the elites. While they were now officially recognized as illegal, small-scale operations owned by local politicians and military officials continued to operate by being able to circumvent national regulations (Obidzinski and Kusters, 2015). Log exports were reduced in the early 1980s to promote value-added products like lumber and plywood and by 1985 log exports were banned entirely for the same reason. From 1970 to 1985, logging concessions, the timber export boom, and the high demand in countries like Japan contributed to rampant deforestation, decreasing Indonesia's forest cover to 119.7 million hectares (63% land area). Another factor contributing to forest loss after 1980 was the transmigration program, which moved families that lived in densely populated areas and didn't own land to rural areas to relieve overpopulation. From 1980 to 1984, the average number of families moved to rural areas was 73,200 annually, whereas prior to 1980 this number was 6,500 annually. The transmigration program coincided with the

expansion of forestry in regions like Kalimantan, providing labor for forest harvesting and crop production and increasing the pressure from agricultural demand in those regions (Tsujino et al., 2016). A ban on foreign owned concessions went into effect in 1984, requiring foreign companies to partner with domestic companies to harvest in Indonesia and allowing the Indonesian government to take extra income from taxes and fees. In 1989 the establishment of plantations for pulp and paper production were incentivized, which were given zero interest loans from the national reforestation fund despite the plantations being created by clearcutting natural forest. Palm oil and other agricultural plantations were later incentivized in the 90s in the same way and the log export ban from 1985 was replaced with a high export tax to stabilize the timber industry (Stanovsky, 2020). With the added pressures of plantation development and agricultural demand, Indonesia saw its rate of deforestation increase even further between 1985 and 1997, reaching a rate of nearly 2 million hectares per year in 1996. This rate was 0.3 million hectares per year in the 70s, 0.6 million hectares per year in the 80s, and 1.0 million hectares per year in the early 90s. Policies for the development of timber plantations were poorly designed and contributed to the degradation of natural forests by providing incentives and subsidies to the private sector for the acquisition of forest land without any further requirements on land conversion. This often led to natural forests being harvested for timber and then abandoned and not used for plantations (Tsujino et al., 2016).

The Asian Financial Crisis of 1997 led to many political and economic changes in Indonesia, and after negotiations for bailouts with the International Monetary Fund (IMF) Suharto was forced to agree to several reforms, one of which being transparency in the use of reforestation funds. Following civil unrest Suharto was forced to resign and the vice president Habibie became the leader of Indonesia's new government (Stanovsky, 2020). In 1998 the

Ministry of Forestry began to become decentralized, transferring authority back to the local governments, which created confusion in governance and led to forest related conflicts related to forest clearance and timber theft. Export restrictions on plywood were removed and export tariffs on logs and lumber were removed, which accelerated forest degradation. Local governing bodies saw forests as an easy source of income, even extending into National Park boundaries, once again accelerating deforestation. Law enforcement was insufficient to keep illegal logging in check (Tsujino et al., 2016). The international demand for wood products continued in the late 90s, especially in China where the domestic forestry laws had just changed, and supply was needed to meet its population's demand and its manufacturing export needs. Indonesia's changes in its forestry sector and increasingly limited supply of sustainably harvested timber would have reduced its ability to meet the international demand, yet studies had shown that the demand was met with increasing amounts of illegal timber (Lang and Chan, 2006). In 1997 and 1998, severe drought, crop failure and wildfires exacerbated by degraded forest land and peat soils led to further forest loss and have been a more frequent issue since (Yong and Peh, 2016). Indonesian export prices did not begin to recover until 2001, after which the log export ban was reimplemented (Stanovsky, 2020). Increased international scrutiny regarding illegal logging and deforestation from the late 90s through the 2000s contributed to improved development of Indonesian forest laws and its participation in international forest programs like REDD+ and a VPA with the EU in 2013, however loopholes and contradictory policy are still an ongoing issue. Stanovsky exemplifies this with the case of a moratorium on clearance and conversion of primary forest implemented in 2011 as part of the REDD+ strategy. This moratorium was extended indefinitely in 2019 but has only contributed to a forest carbon emission reduction of 2.6 to 6.8% as opposed to the pledged 26% and logging permit issuance and the conversion of

primary forest to palm oil plantations have not been reduced. There is ongoing development in policy but a distinct lack of enforcement (Stanovsky, 2020).

**Summary of Relevant Policies**

- Basic Agrarian Law 1960 – moved control of land rights from local to national control (Bedner and Arizona, 2019)
- Basic Forestry Law 1967 – moved control of forestland to the federal government, putting around ¾ of the country (143 million hectares) under federal control (Obidzinski and Kusters, 2015). Provincial governments were initially allowed smaller concessions of 10,000 hectares (Stanovsky, 2020).
- Foreign Capital Investment Law 1967 – allowed and governed foreign investment (Kartawinata et al., 2001)
- Domestic Capital Investment Law 1968 – governed domestic investment (Kartawinata et al., 2001)
- Regulation No. 21 1970 – Stated that forest concessionaire's rights supersede those of local communities (Obidzinski and Kusters, 2015)
- Law 22 1999 – Decentralized government and forest management (Stanovsky, 2020)
- Law 25 1999 – Divided revenue between different levels of government (Stanovsky, 2020)
- Law 41 1999 – Establishes sustainable forest management as the primary principle of all forest governance, defines illegal logging as logging without a permit, and appoints the Ministry of Forestry as the central authority on overseeing forests (Stanovsky, 2020).

- Regulation No. 6 2007 – sets guidelines for legal forest use, approved uses, permit processes, and legal obligations for the harvest and sale of timber products (Stanovsky, 2020)
- Regulation No. 38 2009 – established a legality verification system for timber legality (Stanovsky, 2020)

Indonesia's forests and deeply ingrained in its political and economic history and the forest management policies can be characterized by two distinct eras; the Suharto era's centralized forest management which put authoritarian control of forests in the hands of influential elites and had little regard for the environment, and the post-Suharto reform era which is characterized by more sustainability-oriented policies that are often contradictory or ineffective due to insufficient enforcement.

Indonesia is a country rich in biodiversity with 10% of the world's flowering plant species, 12% of mammal species, 16% of reptiles, and 17% of birds. Lowland forests are the most biodiverse region and the most threatened from land conversion, irreversibly poor forest management, fires, mining, infrastructure development, climate change, and illegal activity. The second most threatened regions are the mangrove forests, which are threatened by illegal logging, infrastructure development and water pollution (Convention on Biological Diversity, nd). Conservation issues in Indonesia are mainly related to deforestation from timber harvest, agricultural expansion, and increasingly common wildfires that start on abandoned post-harvest forest land and peat forests. Mangrove degradation is another conservation issue affecting both terrestrial and aquatic biodiversity. Climate change compounds these problems, making wildfires more frequent and rising sea levels encroach on coastal land formerly stabilized by the

mangroves. Mangroves are also affected by the expansion of palm oil plantations, along with the construction of dams and reservoirs, and has resulted in flooding during rising tides, loss of forest cover, and declines in fish and aquatic species that live in mangrove areas (Sahputra, 2023; Supravitno, 2023).

Apart from forest cover and habitat loss, Indonesia has several tree species that are used for timber products but are protected or at-risk species. Indian/Indonesian Rosewood (*Dalbergia latifolia*) and Ramin (*Gonistylus spp.*) are tropical hardwoods with CITES appendix II restrictions and both have the IUCN status of vulnerable. Indian/Indonesian Rosewood is especially highly valued on the international market for its timber quality, appearance and many uses and is valued domestically in some areas for its bark which is used medicinally. Its slow regeneration rate and high value makes it vulnerable to overexploitation and illegal logging. Black pine podocarp (*Podocarpus neriifolius*) is a tropical evergreen used for furniture and musical instruments with CITES appendix III restrictions and an IUCN status of lower risk. Light red meranti (*Shorea albida*), light red meranti (*Shorea macroptera*), and yellow meranti (*Shorea faguetiana*) all have no CITES listing but an IUCN status of endangered and are used in multiple types of timber products including plywood. Light red meranti (*Shorea albida*) is also endangered due to its peat swamp forest habitat being converted to palm oil plantations and damaged by more difficult to control wildfires. Sandalwood (*Santalum album*) is valued for its strong, durable, and colorful timber as well as its oil and bark used for making medicine, perfumes, soaps, and dyes. Sandalwood has no CITES listing but an IUCN status of vulnerable, as does Merbau (*Intsia birjuga*) which is used in multiple timber products. Non-native plantation species commonly grown in Indonesia include bigleaf mahogany (*Swietenia macrophylla*), grown for its timber, and rubber tree (*Hevea brasiliensis*) for its timber and latex sap. Bigleaf

mahogany has a CITES appendix II listing and an IUCN status of vulnerable, while rubber tree has no CITES or IUCN status. Black wattle (*Acacia mangium*) is another common plantation species in Indonesia, however this is a native species. It is used for particleboard, pulp, and paper but nearly all black wattle products that are commercially available are derived from plantation harvests and it has no CITES or IUCN status (Forest Legality Initiative, nd).

Using timber as a source of income is firmly rooted in Indonesia's history and the shift towards sustainable and legal forest use in the past few decades as often not been smooth. The onset of the Asian Financial Crisis and the bailout negotiations leading to the changes in government occurred at the same time as the change in China's domestic forest policy, which increased the international demand for timber. This combined with the confusion following the decentralization of Indonesia's government and the unclear forest regulations allowed for the establishment of a pattern of illegal harvesting and trade despite the political efforts to make forest governance more sustainable. Provincial level politicians and other harvesting operations immediately taking advantage of the decentralization of forest governance in the early reform era to extend harvesting operations even into the borders of the National Parks isn't the only sign that the habit of overexploitation of Indonesian forests likely still remains. More recently Indonesian politicians and government officials, especially in the Ministry of Trade, have made attempts to overturn forest policy in favor of less restrictive timber trade. In 2015, the Ministry of Trade attempted to waive legality verification requirements for furniture and handicraft exporters, but eventually revoked the decision after backlash from the EU. An attempt to waive legality verification on value added timber products happened again in 2020 to try and stimulate the economy during the Covid pandemic, which was also eventually revoked for the same reason (Jong, 2020).

*Assessment*

Given Indonesia's prominent use of timber exports for income throughout the last century and its sometimes-contradictory forest policies with insufficient enforcement, it seems likely that there would continue to be problems with illegal trade even after the attempts to improve legality and sustainability in the last couple decades. Specifically concerning trade to China, illegal trade is even more likely given China's massive demand for timber imports and its relative lack of legality verification on timber from other countries. However, if a timber product (in this case plywood) was being illegally harvested, processed, and exported from Indonesia to China you would expect that China would have the higher reported values for its imports and that Indonesia would have lower reported values as exporters attempt to conceal their illegal goods, but in this case, we see the opposite. The results in this study show that from 2013 to 2020 Indonesia to China had the second highest discrepancy in the world for the trade of plywood, with a positive discrepancy of 78.8%, which indicates that in terms of value Indonesia reported 78.8% higher export values than China reported receiving each year. The study conducted by Stanovsky on Indonesia's timber trade showed this same discrepancy pattern in plywood starting in 2010 and dropping off in 2018, while lumber and logs showed a negative discrepancy (meaning China reported higher values). To investigate this further, the annual reported values for each product by both countries were examined and it was found that Indonesia began reporting much higher values in plywood than China starting in 2010 and becoming less extreme in 2018. During this same time China reported higher values than Indonesia in both logs and lumber, with Indonesia not reporting any logs going to China at all until 2019. Log exports were banned in Indonesia for much of this time, changing in 2017 to an export restriction that allowed exports of plantation

logs (ITTO, 2017). The Indonesian SVLK timber legality assurance system went into effect in late 2009 (Jong, 2020), and with the high discrepancy in plywood starting in 2010, it may be related to the implementation of the SVLK. Another interesting correlation is that the drop from very high positive discrepancy to moderate positive discrepancy in plywood happened in 2019, the same year that the negative discrepancy in lumber dropped slightly and the first year that Indonesia had reported any export value at all for logs going to China. Based on this information the high positive discrepancy in plywood exports to China after the implementation of the SVLK could be related to the negative discrepancy in logs and lumber, and it could be caused by the misreporting of product type. However, if this were the case the method of obscuring logs as plywood is uncertain.

### *Comparisons to Existing Risk Assessments*

The two major resources for assessments of the risk for illegal trade in timber are the Illegal Logging and Associated Trade (ILAT) tool by Forest Trends and the risk ratings by Preferred by Nature. Both risk assessments use factors other than trade discrepancy analysis, so comparisons between results of this study to the risk scores from Forest Trends and Preferred by Nature would give an estimate of the efficacy for using trade discrepancy in risk assessment. Forest Trends' ILAT considers factors related to political governance, a country's association with armed conflict, and export restrictions to determine a risk score on a 100-point scale, where 50 to 100 are evaluated as high risk. For the exporters in the cases analyzed for this study, the ILAT shows New Zealand as low risk (1.6/100), Hong Kong as low risk (6.8/100), Ghana as high risk (55.9/100), and Indonesia as high risk (51.5/100) (Forest Trends, 2021). In Preferred by Nature's risk assessments the scores are on a reversed 100-point scale, with 100 being low risk.

The Preferred by nature scores are based on the perception of corruption, export restrictions, prevalence of armed conflict, and the amount of certified forest area. Preferred by Nature assigned the following risk scores to the exporters from the cases; New Zealand as low risk (100/100), Hong Kong was included in China and was not given its own score, Ghana as high risk (35/100), and Indonesia was also not given a score because of its FLEGT status (Preferred by Nature, nd.). Both Forest Trends and Preferred by Nature assign overall timber risk scores that are independent of the product type and trade partner. Like the results of this research, Ghana was shown as high risk by both Forest Trends and Preferred by Nature while Indonesia was also shown as high risk by Forest Trends. Both Forest Trends and Preferred by Nature show New Zealand as low risk and Forest Trends shows Hong Kong as low risk. The high-risk assessments for Ghana and Indonesia support the findings in their respective case studies while the assessments for New Zealand and Hong Kong emphasize that other factors aside from illegal trade can influence discrepancy and that discrepancy analysis is useful for a rough estimate.

# Chapter 8. Conclusions

First, this study developed a visual representation for the risk of illegality in timber trade flows based on trade discrepancy analysis and market share data with the intent of clearly displaying risk assessments for bilateral trade flows on a global scale. Doing this allows users to highlight potential areas of concern for further investigation or to track the effectiveness of policies in reducing illegality over time. The generated maps generally match the findings of previous studies that have analyzed timber legality in specific trade flows. Example comparisons included Ghana to India, Indonesia to China, and Peru to multiple trade partners, each between the years of 2014 to 2020. Findings of very high risk for the illegal trade of logs and lumber exported from Ghana to India match with the results of trade analysis by Forest Trends. The risk

maps for trade between Indonesia and China showed very high risk for illegal trade for logs and lumber and moderate risk for plywood, while Stanovsky's research on Indonesian trade also puts log and lumber trade with China at high risk and plywood being high risk during the period of 2012 to 2018 and low risk in other years. Since the time frame used in this study's example maps is from 2014 to 2020, the low risk in 2019 and 2020 combined with the high risk in prior years led to an evaluation of moderate risk overall. The third set of example maps showed Peruvian exports of logs and lumber to China and plywood to Mexico were high risk, each of which match the results of Pardo-Herrera's research, however Pardo-Herrera's indication of high-risk trade from Peru to the Dominican Republic could not be assessed by this research due to a lack of data for the Dominican Republic. Since trade discrepancy requires data from both sides of a trade flow, unavailable or unreported data for a country or product type is a limitation.

Next, this study determined the highest risk trade flows for each product type for the data between 2014 to 2020. Trade flows with discrepancy scores that fall between -0.5 and 0.5 standard deviations of the mean were omitted to ensure that trade flows could not be considered as highest risk if they have low discrepancy but very high market share (since Risk = Discrepancy * Market Share). A trade flow would need to have both high discrepancy and market share to be highest risk. For each product, trade flows were ranked according to risk scores and the ten highest risk trade flows were displayed graphically along with discrepancy and market share values. Rankings showed trade flows with the highest risk of illegality being Hong Kong to China for logs, Ghana to India for lumber, and China to the EU for plywood. Case studies were conducted on each of these trade relationships to determine if the evaluation of potential risk was accurate or influenced by other factors unrelated to illegal trade. Trade of logs between Hong Kong and China is part of a triangular trade pattern with logs originating from

New Zealand and being shipped through Hong Kong on the way to China. Hong Kong itself has very little forest to provide timber internationally and often acts as a re-exporter between China and its trade partners. The second highest risk ranked trade flow is New Zealand to Hong Kong, which further supports this scenario. In this case it was determined that the risk score was inflated by reporting issues associated with re-exporting and likely not illegal trade. New Zealand would report exports as going to Hong Kong, Hong Kong did not report receiving the logs from New Zealand and China reported the imports passing through Hong Kong as coming from New Zealand. This pattern of reporting created high levels of discrepancy in both trade flows. In the case of lumber trade from Ghana to India, the high risk of illegal trade seems to be an accurate assessment. Ghana has a log export ban, so exporters are motivated to report illegally exported logs as lumber, whereas India has low log tariffs which encourages importers to report receiving logs to save money, even if they are receiving lumber. Opposing incentives on each side of the trade flow make it difficult to determine which product is being traded. In the situation where Ghana is misreporting, it could be illegal due to either environmental or financial regulation evasion, whereas in the situation where India is misreporting it would be financial evasion. The third case study of plywood trade from Indonesia to China suggests another accurate assessment for the risk of illegal trade. Indonesia has a long history of treating its forests as a source of income on the international market and even though its forest policy has changed much in the past few decades the policies still have contradictions and enforcement problems. China also lacks forest policy for ensuring that timber imports are from legal sources. The positive discrepancy for plywood trade jumped to high levels after the implementation of Indonesia's legality verification system in late 2009 and was not reduced until 2019. The reduction in discrepancy coincided with some reduction in discrepancy for logs and lumber as

well, both of which have negative discrepancy. Indonesia's overreporting of plywood exports that started shortly after the start of legality verification, and the underreporting of logs and lumber suggests that there may have been misreporting of product type to avoid regulations. If this is the case, then the high-risk score for Indonesia's plywood may instead be an indicator of illegal activity involving logs or lumber.

In a typical case of illegal trade, the importer would be reporting the higher values while the exporter would underreport. This would be the negative discrepancy, colored red in the graphs for the highest risk trade flows. However, in the graphics for highest risk trade flows, positive discrepancy (colored green), was more common than expected. Based on the results of the case studies, this could partly be caused by factors unrelated to illegal trade like shipment costs or re-exporting such as in the case of logs going from New Zealand to Hong Kong to China. It could also potentially be indicative of misreporting of product type, like in the case study of trade from Indonesia to China, signaling illegal trade occurring in a different product than the one reported. Discrepancy analysis is useful as a rough estimate for the presence of illegal trade but as shown by the cases in this study further investigation is often required to ensure that the discrepancy isn't being influenced by other factors. Fortunately, other factors that could impact the results of discrepancy analysis are typically noticeable or easy to discover if they are present.

## Appendix: App Link and User Information

https://dccraw2.shinyapps.io/Shiny/

Countries filled in with color are trade partners of the selected country and have sufficient data to determine risk scores. The selected country and non-trade partners or countries lacking data remain gray. Since members of the EU report their data together, they are treated as one

country. Risk scores indicate the risk of illegal trade based on the discrepancy in reported trade values and global market shares and are shown in shades of red corresponding with numbers on a color scale.

| Average Risk Score | Level of Risk |
|---|---|
| 0 | Minimal |
| 5 | Low |
| 10 | Low-Moderate |
| 15 | Moderate |
| 20 | Moderate-High |
| 25 | High |
| 30 | Very High |

Risk scores convey level of risk for illegal trade but do not assign fault to either country and further investigation is required to determine causes. Observing the same trade flow from both the importer and exporter perspectives may yield different risk evaluations because of the differences in global market shares for importers and exporters. Since many more countries import timber than export it, global market shares for importers may reach near zero numbers making the importer perspective less viable for assessing risk.

**Global Risk Charts**

This section shows the ten highest risk trade flows for the selected product based on the discrepancy between the two country's reported trade values and its portion of the global market for that same product. All trade flows in this section follow the format of "exporter_importer". The chart at the top of this section shows a comparison of the ten highest risk trade flows. The

chart at the bottom left shows the average discrepancy percentage between the two country's reported values. A negative percentage shows that the importer reported higher values of trade while a positive discrepancy shows the opposite. The chart at the bottom right shows the percentage of the global market occupied by the trade flow. This percentage is already out of 100%, so a 0.81 would be 0.81% of the global market and not 81%.

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