Timber Trade Policy and Illegality:
A study of data discrepancies in Indonesia's top trade relationships.

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Abstract

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Illegal timber trade is tied to forest loss and degradation, and contributes to negative impacts on social, economic, ecological, and climate systems. Despite growing international awareness and policies designed to prevent illegal timber from entering markets, the problem is persistent and difficult to detect. This study expands on previous efforts to identify signs of illegality in national trade discrepancies through analysis of imbalances between import and export data reported by Indonesia and its largest national timber trade partners.

The goals of this research are to 1) Measure the effectiveness of national policies in curbing trade of illegal timber products from Indonesia, 2) Identify Indonesia's national timber trade partners and products that exhibit a high risk of illegality, and 3) Evaluate the efficacy and appropriateness of discrepancy analysis as a means to estimate and pinpoint illegal timber trade. We analyzed trade data for logs, lumber and plywood, as well as relevant policies in Indonesia and eleven of its most important timber trade

partners from the years 2000 - 2019. Through data visualization and statistical analysis, we identify that Indonesian lumber exports are at the highest risk of illegality; that China is Indonesia's highest-risk trade partner; that specific national policies do contribute to discrepancy reduction between specific nations; and that single-nation trade import policies may drive leakage of illegal timber from regulated to less regulated markets.

Further work to more precisely quantify the extent and sources of "normality" in discrepancies would enable a clearer parsing of illegal or risky discrepancies. Understanding this data to be non-normally distributed, future application of nonparametric statistical testing would be a valuable contribution. Additional research on the presence and magnitude of leakage resulting from specific policies will be vital to ongoing efforts to reduce tropical forest loss resulting from illegal trade.

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Section 1. Introduction

Forests are integral to life on earth, perhaps best illustrated by the common refrain that forest ecosystems are the most biodiverse habitats (Wilson & Peter 1989; UN-REDD Programme 2018; Rainforest Trust 2017) and the largest natural carbon stores (Global Forest Atlas 2017). Defined as tree canopy loss with no natural or human-facilitated regrowth, over 90% of global deforestation occurs in the Tropics and Sub-tropics (Curtis et al. 2018), where industrial agriculture, subsistence agriculture, and infrastructure are the three dominant drivers globally, with a good deal of regional and location variation (UN FAO 2016). Thus, the tropics suffer the majority of global forest loss, but the problem is global in nature. Demand for wood products from developing and forest-rich tropical nations is driven largely by consumer demand in wealthier and more highly developed nations. Therefore, national policies in all nations with a role in producing, transporting, manufacturing, and consuming tropical timber contribute to the dynamics that protect or threaten sustainable tropical forest management.

This thesis takes Indonesia as a case study for evaluating the effectiveness of recent national and international efforts to reduce illegal timber trade, which contributes to deforestation, biodiversity loss, and threatens efforts at nature-based carbon storage. Through an examination of trade data discrepancies between Indonesia and its timber trade partners, this research seeks to 1) Measure the effectiveness of national policies in curbing trade of illegal timber products from Indonesia 2) Identify Indonesia's national timber trade partners and products that exhibit a high risk of illegality, and 3) Evaluate the efficacy and appropriateness of discrepancy analysis as a means to estimate and pinpoint illegality.

Section 1 establishes the context, framing, and need for this research. Section 2 begins with a qualitative history of Indonesian forest policy, coupled with summary analysis of trade data back to 1960 from the UNFAO. This puts my further research into historical context and provides the basic social and economic understanding necessary for later detailed analysis. Section 3 is an overview of Importer nations' policy history since 2000, providing the basic framework for analyzing the effectiveness of specific policies. Section 3 is a discussion of methods used in data collection, cleaning, manipulation, and analysis, including discussion of the in-process adjustments made to this research design. Section 4 provides a preliminary investigation of the data prior to construction of Discrepancy Rates and Discrepancy Scores, establishing the relative magnitude of trade Partner and Products, and identifying broad trends for further analysis. Section 5 described the specific methods of data manipulation and analysis applied in analysis of Discrepancy Scores. Section 6 presents the full analysis of the Discrepancy Scores data in two phases: Forest, I emphasize visualizations as a means of identifying trends, policy influence, and risk of illegality in Indonesia's trade partnerships. Informed by this visual analysis, I then construct and run six series of tests for statistically significant differences in trends between policy time periods, partnerships, and product groups. Section 7 synthesizes analysis into a set of conclusions and discussion of valuable further research.

Global Forest Loss & Indonesia

Tropical deforestation by humans poses a great risk to present biodiversity, future climate stability, and is connected to human rights problems in the developing world. Global forest cover has declined by 20% since 1900 as a direct result of human behavior and population growth (Khokar & Tabary 2016). Forest destruction and overuse imperil three-quarters of the world's threatened species (Maxwell et al. 2016). The tropics store 55% of global forest carbon (Pan et al. 2011) but have been destroyed at an alarming rate in recent years (Weiss & Goldman 2018), resulting in a transition from net sink to a net source of atmospheric carbon for the first time (Baccini et al. 2017).

Human systems subject forests to widely varying and often conflicting views, practices, demands from economic and governance systems. While currently a source of 8% of global carbon emissions are due to tropical tree cover loss, forests could "provide 23% percent of the cost-effective climate mitigation needed before 2030" (Gibbs et al. 2018). Sustainable management of the world's forests could secure 75% of fresh water supply (UN-REDD Programme 2017) and greater security for forest-dependent livelihoods of 1.6 billion people (United Nations 2016). Despite agreement within high level international governing bodies, tropical forest loss persists (Curtis et al. 2018).

Indonesia is second only to Brazil in tropical forest coverage, accounting for 73% of regional rainforest coverage. Deforestation is a particularly important and ongoing threat in Indonesia (Margono 2014; Jong 2021a), which accounts for 75% of regional deforestation from 2002 - 2019 (Mongabay 2021). Illegal timber markets are an ongoing challenge despite policy efforts to curb timber illegality (Wijaya et al. 2017) and declining trends of deforestation in recent years (Jong 2021b). Palm oil plantations and fires, which are often a precursor to palm or other agricultural use conversion, are the leading causes of Indonesian forest loss (Austin et al. 2019). Section 2 discusses in greater detail the modern history of forest governance and timber trade that make Indonesia a particularly fascinating and globally influential case study.

Illegal Logging & Wood Product Trade

49% of tropical deforestation between 2000 - 2012 "was due to illegal conversion for commercial agriculture" (Lawson et al. 2014 p.2); Indonesian commodity agriculture, primarily palm oil, drives between 40% (Austin et al., n.d.) and 66% (Ritchie et al., n.d.) of forest loss; small-scale agriculture, also largely palm oil, accounts for 9-30%; and timber products between 13-20% (Curtis et al. 2018). Much of this forest loss and land conversion is also fire-related, with conversion rates increasing after large forest burn years and accounting for between 2 to 20% of forest loss (Austin et al., n.d.; Curtis et al. 2018).

As illegal timber trade is largely made possible by ineffective, unenforced, nonexistent, or corrupt government systems, most interventions currently attempted or imagined rely on improved governance structures at local to global scales (Chatham House 2021). Often associated with illegal land conversion, harvest, or transport early in the supply chain, illegality may reside in downstream products of any form including round logs,

dimensional lumber, plywood and veneer, charcoal, pulp and paper, chips, and furniture, many of which can be very difficult to trace and identify with illegal origins or processing (Nellemann et al. 2014). This poses a large challenge to domestic and international market governance and law enforcement.

Nonprofit financial crime watchdog Global Financial Integrity put simply in a 2017 report, “Illegal Logging is the most profitable natural resource crime,” (May 2017 p.xiii). The World Bank cites estimates of illegal timber market value at between $30 - $157 Billion annually (Montero et al. 2019). Most illegal timber trade is conducted by formal companies with fraudulent methods and accrues the majority of resulting profit to financiers and corporations rather than governments and local communities (Montero et al. 2019). Further, illegal timber has lower production costs and depresses global legitimate market prices (Seneca Creek 2004; Gan et al. 2016) resulting in combined revenue losses on Indonesia timber from depressed prices and unpaid taxes totaling between $600 million and $5 billion annually through 2004 (Seneca Creek 2004). While estimates of precise quantity and value are inherently speculative given the unofficial and unaccountable nature of illegal markets, it is widely agreed that illegal timber trade has a large negative impact on markets for legitimate timber products.

Though economic theory suggests that marginal cost would exceed market price as timber scarcity increases over time, preserving some baseline forest population, Gan et al. (2016) explain that the most valuable species are likely to be exceptional to such simple market behaviors and therefore not protected by market forces from extreme overexploitation or extinction. Threats to tree species and forest ecosystems are likely even more tenuous than this would suggest, when taking into account the “tipping point” theory positing that irreversible ecosystem collapse may occur rapidly once biome-specific thresholds are exceeded (IPCC 2014). Human health costs and associated economic costs are also likely to increase with deforestation and ecosystem degradation, but these go largely unaccounted for as economic externalities (Myers et al. 2013; Garg 2014). While many attempts are made to shift economic incentives away from illegal forest practices, these are greatly outweighed by the financial investments in status-quo global forest practices (New York Declaration on Forests 2017), leaving a large gap for forest governance systems to fill to achieve a “fair” global wood products market.

Illegal Logging has long been an issue for Indonesia. 63% of Indonesia’s land area is designated Forest Area, of which 57% or 68.8 million hectares are designated as Production Forest (Nurbaya 2018). National Forests and timber resources were an integral component of nation building under President Suharto from the 1960s to the 1990s. Despite international and domestic efforts to reduce forest loss and crack down on illegal timber trade, Indonesia’s forests face ongoing threats from policy and rights disagreements, inconsistent enforcement of illegality protections, growth in demand especially for pulp and palm oil, and the difficulty of detecting illegality despite. To illustrate the severity of the problem, Indonesia lost 24% of its forest cover between 1990 - 2005 (Singer 2009); lost $70 billion in tax revenue to illegal trade between 2007 - 2011 (Human Rights Watch 2013); and estimates that illegality in timber supply were at

40% in 2006 were a marked decrease from an estimated 75% in 1999 (Lawson & MacFaul 2014). While this study supports the literature in finding a decreased risk of illegality in Indonesian timber supply over time, the pressure on natural forests remains high and the stakes increase as natural forested area continues to shrink (Wijaya et al. 2019). Ongoing challenges surround Indonesia's efforts to manage its forests sustainably while meeting simultaneous demands for carbon emissions reductions, habitat preservation, and commodity production (Tacconi & Muttaqin 2019; Jong 2021b).

Timber-related law and regulation can be found at every level of government from international to local, forming a complex patchwork rather than a cohesive global governance system. To further understand the national and legal systems which seek to address illegality in Indonesian timber trade, Section Two examines the modern history of the Indonesian Forest Products industry, and Section Three reviews relevant national policies adopted, amended, and enforced between 2000 - 2019, a period during which Indonesian wood products trade has seen a decline in illegal activity.

Section 2. Indonesian Forest Policy Review

A review of Indonesian forest policy and wood products trade provides qualitative context and grounds for developing hypotheses of the impact of policy on forest commodity trade, forest health, and illegal timber trade. Figure 1 provides a graphical supplement to the brief narrative history presented here.

Figure 1: Indonesian Wood Exports History

Suharto & the New Order

Prior to the Suharto presidency and his New Order regime, forest resources and governance were located at provincial and local levels (Ross 2001; Thee 2009; Obidzinski & Kusters 2015), a reflection of the dispersed nature of society in the Indonesian archipelago prior to and throughout Dutch colonial rule. As Dutch rule came to an end, national integrity was far from guaranteed, giving rise to efforts toward national unity and centralization to retain provincial membership. Most pertinent of these policies was the 1960 Basic Agrarian Law, which nationalized *adat* land rights - at once enshrining the patchwork system in national law and removing authority to enforce this law from the local to national scale. (Ross 2001; Bedner & Arizona 2019). This tension between national and local control over forests is a defining characteristic of Indonesian forest policy and commodity production.

Suharto sought to leverage the mostly non-industrialized national timber resources to bankroll modernization and stabilization of the Indonesian nation. The 1967 Basic Forestry Law centralized forest governance, claiming direct federal authority over an area comprising about three-quarters of national land area (Bedner & Arizona 2019; Obidzinski & Kusters 2015), though for a time allowing provincial governments to assign concessions up to 10,000 hectares (Ross 2001). This allowed provincial governments and local loggers to continue to benefit from smaller concessions, while the federal government engaged in a concerted effort to attract foreign investment in timber

extraction and industry development “with the main aim being to increase revenues in support of national development programs.” (Obidzinski & Kusters 2015 p.534). Further policies in the early 1970s adjusted the minimum concession size to 50,000 ha, effectively eliminating provincial and local rights; and gave preference to commercial over local concessions, eliminating all traditional *adat* rights (Ross 2001; Barr 2006). It also enabled Suharto to build a system of patronage that directed revenues to the federal government and maintained tight loyalty to Suharto among government officials, military leaders, and private companies (Ross 2001; Smith et al. 2003; Nurbaya 2018). These policies and structured patronage were highly preferential to private, mostly international logging operations and were primarily responsible for the meteoric rise of Indonesian log exports through the late 1970s (Singer 2009; Barr et al. 2006).

Figure 1 illustrates the economic results of centralizing forest governance and nationalizing the timber products industry. During Indonesia’s early years and through the 1980s, log exports were instrumental in constructing domestic political systems, international trade relationships, and financing Indonesia’s governmental and industrial systems under Suharto (Ross 2001; Barr 2006; Singer 2009; Smith 2010). Given the wealth of natural forests and relatively low level of industrial development at the beginning of this period, logs proved an abundant cash crop requiring minimal processing before going to market.

But the relatively low price for log exports led to dissatisfaction compared to the much higher revenues available for processed timber, which Indonesia largely lacked infrastructure to produce (Thee 2009). Log export taxes were increased from 10% to 20% in 1978 (Thee 2009); further tax increases, limits on log exports and restriction of quotas to firms with processing facilities 1981 (Thee 2009; Ross 2001); and an outright log export ban took effect in 1982 (Thee 2009; Ross 2001; Barr 2006; Fry & Honnold, 2010). The policies had the intent to build incentive for domestic processing and increase revenue to Indonesian government which saw its share of profits from timber concessions shrink from 25% to 5% between 1973-1986 (Ross 2001), and to social elites who owned wood processing facilities (Prasetyo et al. 2012; Barr 2006). Barr explains “The ban had two far-reaching effects on the structure of Indonesia’s timber industry...it effectively concentrated control over the nation’s...timber concessions [and] it triggered a significant influx of investment into Indonesia’s wood processing industry.” (Barr 2006 p.26-27) The central government began collaborating with the Indonesian Wood Panel Association, APKINDO, in 1976, giving it the mandate to control collective industry marketing and granting oligopolistic control of plywood exports. These incentives to develop processing capacity to control markets drove the plywood industries to overtake log exports in value by 1982-1983.

1984 brought a new ban on foreign-owned timber concessions, requiring that foreign companies establish joint ventures with Indonesian timber companies, further enabling domestic entities to retain revenues and funneling additional funds to federal agencies through taxes and fees (Thee 2009). The aggregate effect of protectionist trade policies both enabled the rise of the Indonesian plywood industry and foreshadowed its eventual

decline after the Asian Financial Crisis exposed the Indonesian plywood market to international competition for which it was ill-prepared (Singer 2009).

Two decades of intensive primary forest harvest and systemic mismanagement of the federal reforestation fund left vast tracts of cleared land (Ross 2001; Smith 2003). In 1989, Indonesia began promoting timber plantations with the aim of establishing a sustainable source of fiber for the nation's rapidly growing pulp industry (Barr 2006). Incentives for pulp and paper plantations included zero-interest loans from the Reforestation Fund, even while the early stages of pulp and paper industry growth relied heavily on clearing of natural forest (Harwell 2003). Around the same time and into the 1990s forest conversion to Palm oil and other estate crops were also incentivized. (Barr 2006). This conversion laid the groundwork for the eventual predominance of pulp and paper as direct wood products, and palm oil as the eventually dominant agricultural commodity.

The early 1990s saw the outright log export ban replaced with a high export tax (Forest Legality Initiative [FLI] n.d.b.), in large part an effort to stabilize the Indonesian wood manufacture industry as it faced increasing international pressure and began to encounter limitations to sustainable supply (Singer 2009). 1993 saw the early entry of timber certification programs in the governmental LEI Ekolabel and private Forest Stewardship Council. These programs had the tricky role of seeking to balance scrutiny over forest practices with pressure on the timber industry to once again buoy an ailing national economy (Wibowo & Giessen 2018). Despite increasing concern over conservation issues during this period, these nascent efforts to control rampant deforestation were far from successful. Indonesia lost 24% of its natural forest cover from 1990 - 2005 (Singer 2009) amid increased global demand, over-investment in domestic manufacturing capacity, and often-contradictory policy agendas and enforcement.

The Asian Financial Crisis hit Indonesian markets in 1997, devaluing the Rupiah by 32% and prompting bail out discussions with the IMF. Suharto was forced to agree to deep reforms, including dismantling APKINDO, before receiving a $43 Billion IMF loan in 1998. Among the reforms were an agreement to auditing and greater transparency in the Reforestation fund and dismantling of APKINDO (Singer 2009; Barr 2006). Suharto was eventually forced to resign amid riots and looting that began to take a racial turn against the ethnic Chinese population perceived as central to systemic corruption under Suharto. Vice President Habibie succeeded Suharto and the so-called Reform Era had begun.

The Financial Crisis drove a steep decline in Indonesian wood product export value that did not begin to rebound until 2001, a year which also saw the re-enactment of the outright Log Export Ban (FLI n.d.b; Thee 2000). No longer bolstered by protective domestic policies, the plywood industry struggled to maintain its competitive advantage. Export value of the plywood industry was overtaken by paper and paperboard in 2005 with the help of national promotion. Again without a concerted effort to guarantee sustainable supply commensurate with demand from manufacturing capacity that

became the main driver of Indonesian illegal logging in through the 1990s and early 2000s (Obidzinski et al. 2007).

Reform Era to Present

Under national and international pressure to restore local and regional authority after three decades of tight central control under Suharto, Habibie enacted Laws 22/1999 and 25/1999. Law 22/1999 decentralized government generally and forest management specifically; Law 25 divided revenues between different levels of government (Barr 2006). However, the struggle to define Indonesian forest governance is clear in policy dissonance immediately following Suharto. Law 41/1999 runs counter to Laws 22 and 25/1999, which sought to reassert the central role of the Ministry of Forestry in overseeing the nation's forests and did so in part by defining illegal logging as unpermitted forest product harvest. (Barr 2006; Wollenberg & Kartodihardjo 2002; Indrarto et al. 2012). Law 41 also establishes Sustainable Forest Management (SFM) as the principle of all forest governance (ADAWR & Indonesia 2018). This struggle between central & dispersed authority, and the simultaneous grappling with pressure to reduce forest destruction and illegal harvest (Prasetyo et al. 2010), are best understood as latent throughout the Suharto years rather than entirely new upon his leaving power. However, it is clear that the Reform era was characterized by a significant horizontalization of forest governance overall (Tacconi 2004; Indrarto et al. 2012; Siscawati et al. 2017; Smith et al. 2003; Prasetyo 2012). Describing this period of transition, Barr et al. (2006 p.45) write,

> "...legislative dissonance has allowed government policymakers at various levels of the Indonesian state to claim legitimacy for policy positions that are often diametrically opposed to one another...Such competing claims have been symptomatic of the intense political struggles that have framed the decentralisation process in Indonesia's forestry sector over the last several years."

Steep log export taxes were removed in 1998 in an effort to increase local-level and small-holder revenue where timber producers lacked manufacturing capacity; a full log export ban was then enacted in 2001 and implemented in 2002 as a result of lobbying by the timber manufacture industry's arguments that a ban would reduce illegal log trade and benefit concession holders as well as manufacturers. Tacconi et al. (2004 p. 13) argue the ban has been ineffective both because Indonesian export log volume was insufficient to affect market prices, and that enforcement was "ineffective in stopping the export of logs." Contrary to the widely held view that log export bans reduce illegal trade, Resosudarmo & Arief (2006) argue that the Indonesian log export ban is inefficient both in reducing deforestation and in revenue and jobs creation. The ban was expanded to include sawnwood (lumber) in 2004 (FLI n.d.b).

The combination of growing international scrutiny over illegality (World Bank 2003; Environmental Investigation Agency [EIA] & Telepak 2005; Wibowo & Giessen 2018) and Presidential Instruction No 4 of 2005, led to crackdowns on illegal log trade by Indonesia's Ministry of Forestry (Obidzinski et al. 2007; Prasetyo 2012). This contributed

to a decrease in cross-border timber smuggling by as much as 70% between 2005-2007 (Obdiszinski et al. 2007) and a decrease in illegal trade by as much as 75% in the decade preceding 2009 (Lawson & Macfaul 2010). Obidzinski et al. (2007) argue, however, that over-border trade is peripheral to a fundamental lack of legal supply to satisfy Indonesia's domestic timber processing capacity; Lawson & Macfaul (2010) add to this that the majority of illegal timber is consumed in domestic manufacture and obscured by the time it leave the country.

The international context was also shifting contemporary to this era of change in Indonesian governance. The 1990s and early 2000s saw an increase in international efforts to reduce illegal logging and combat deforestation. Indonesia joined the UN Convention on Biological Diversity ("CBD") and the Convention on International Trade in Endangered Species and Wild Fauna and Flora ("CITES") and UN Framework Convention on Climate Change ("UNFCCC") in the early 1990s; the UN Forum on Forests in 2000; UN-led financing mechanisms for Reducing Emissions from Deforestation and Forest Degradation ("REDD+") in 2007; and the EU FLEGT process beginning in the early 2000s. (Indrarto et al. 2012)

Each of these international mechanisms aims directly or secondarily to reduce natural forest and other natural habitat loss; however, their efficacy is complicated by Indonesia's persistent forest loss as the growth in Indonesia's legal frameworks and regulatory policies is often contradictory or leaves significant loopholes that allows for further, often technically legal, forest loss. Indrarto et al. (2012 p.17) summarize, "...good intentions with regard to environmental management have not been supported by adequate concerted efforts to improve the infrastructure, capacity and governance needed to realize [Indonesia's] international commitments."

Amid increased global concern and motivated also by the desire to protect diminishing timber supply for value-added manufacturing industry (Singer 2009), Indonesia's President Yudhoyano mandated an increase in scrutiny on timber supply chains and stricter enforcement of domestic illegality controls.

Despite ongoing efforts to build improved forest governance, the themes of policy misalignment or contradiction, underinvestment in regulatory systems and enforcement, and leaky implementation are repeated across our review (Barr et al. 2006; Ross 2008; Kartodihardjo et al. 2009; Santosa et al. 2010; SATGAS 2012; Indrarto 2012; Enrici & Hubacek 2016). The gap between policy intent and impact are perhaps most glaring in the simultaneous reduction of illegal logging (Ministry of Environment and Forestry [MOEF], 2009; Lawson & MacFaul 2010) and the continuation of deforestation (Indrarto et al. 2012), indicating that timber from unsustainable forest products continues to find legal entry into markets despite these frameworks. National and international efforts to curb illegal logging and deforestation continue, and with incremental cause for optimism.

This increased international scrutiny and domestic enforcement preceded the introduction of REDD+ mechanisms in 2007 to reduce emissions from deforestation and

degradation (Machfudh 2011; Indrarto et al. 2012; SATGAS 2012; Santosa et al. 2013). This was backed by a $1Billion investment commitment from Norway and a national commitment to reduce greenhouse gas emissions from deforestation by 26% - 41% by 2020, while growing GDP (SATGAS 2006; Busch et al 2014). Government Regulation No. 6 of 2007 sets explicit guidelines on legal subjects entitled to forest use, approved uses and permitting processes, and related rights and obligations of harvest and sale of forest products.

Since Regulation 6/2007, Indonesia's Ministry of Forestry (which became the Ministry of Environment and Forestry, "MOEF" in 2014) has issued a number of implementing regulations establishing processes and use of timber from production forests (ADAWR & MOEF 2018). Among these, Regulation No. P.38/2009 established the government's timber legality verification "SVLK" (or "TLAS" when translated to its English acronym) and Sustainable Forest Management Certificate "PHPL" systems (Wibowo & Giessen 2018). The SVLK scheme is a mandatory government certification applied in parallel to pre-existing voluntary private certification scheme through Forest Stewardship Council (FSC) and Lembaga Ekolabel Indonesia (LEI), both founded in 2003 and issuing first Indonesian concessions in 2008 (Wibowo & Giessen 2008). SVLK was simultaneous with early discussions with EU FLEGT, and SVLK eventually became the "core unit" of the Voluntary Partnership Agreement (Wibowo & Giessen 2018 p.33; Nurkomariyah 2015; ADAWR & MOEF 2018). The 2012 Forest Product Export Regulation put the SVLK into implementation, defining wood products into two groups (all of the products contained in this study are included in "Group A"), and requiring that exporting companies complete specific legality assurance documents and independent monitoring and evaluation of both companies and the entire SVLK system (UN 2014; Obidzinski et al. 2014).

Indonesia's challenges with leaky forest governance and contradictory policy are exemplified through one particular policy that arose amid the formation of REDD+, SVLK, and EU FLEGT processes. As part of the national REDD+ strategy, President Yudhoyano declared a 2-year moratorium on clearance and conversion of Indonesia's primary forests that took effect in May 2011 (Gingold 2011; Busch et al. 2014). This was extended 3 times until 2019 when President Widodo made it permanent (Jong 2019). The moratorium, however, only contributed to forest sector emissions reductions of 2.6-6.8% compared to the 26% pledged under Indonesia's REDD+ commitment (Busch et al. 2014); and has not been successful in reducing logging permit issuance or permanent conversion of forests primarily to establish palm oil plantations (Jong 2019; Mongabay & The Gecko Project 2017).

These shortcomings have their roots in the recurring challenges to design and enforce national forest policy that is robust to differing demands and loopholes at the local level. These include political influence and inaccuracies in periodic forest remapping (Mongabay 2011), a rush to issue permits before the moratorium took effect, and the practice of partially burning primary forest to downgrade its official designation and open it for permitting (Jong 2019). All of these practices have some degree of legal

application, highlighting the gap between efforts to combat illegal logging and to stop deforestation and degradation.

The conversion moratorium remains an evolving case, and certain loopholes may have been addressed by a 3-year freeze on new palm oil leases signed by Widodo in 2018 (Mongabay 2018; Jong 2019). In contradiction to tightening conversion policies, however, is an ongoing lack of enforcement of existing policy. Reporting by EIA (2021) uncovered illegal activity and spurred about one year of enforcement actions, but that legal process failed to confiscate timber, strip licenses, or stop operations by the guilty companies. Further illustration that Indonesian forest policy remains contentious and evolving, in 2020 the Ministry of Trade announced a regulation to end the SVLK legality certification applied to all forest products and underpinning EU FLEGT licensure (EU FLEGT 2017), only to reverse course as opposition mounted from uninformed elements within Indonesian government, NGOS, international governments and forest product industry (Jong 2020b).

Section 3. National Partner Policies

As international trade data are the central piece of this research, it is necessary to establish a basic understanding of the laws affecting international timber trade between Indonesia and its largest trade partners. This section is a succinct overview of timber import policies adopted during the period studied (2000 - 2019) by each importing nation included in this study. I endeavor here to be comprehensive in inclusion of policies, but not exhaustive in the level of detail presented. This section collects the specific details of each policy likely to impact the presence and magnitude of illegal timber trade, including enactment and implementation dates, high-level structural details such as phase-in periods, product coverage, and enforcement mechanisms. We also include here notable enforcement cases which may indicate the respective magnitude of effects on trade trends from enactment, implementation, and visible enforcement.

Top Wood Products Trade Partners

Figure 2: Indonesia's Top Timber Trade Partners by Export Value

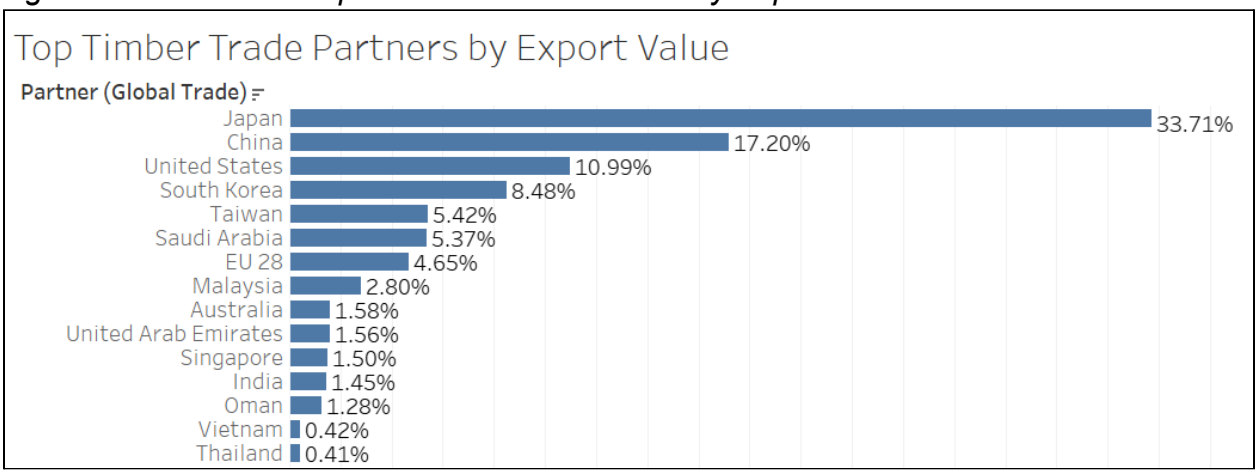


Figure 2 shows a summary of Indonesia's top wood products trade partners by percent of total export value from 2000 to 2019. Smaller trade partners are not shown in Figure 2, but percentages are of Indonesia's total timber trade export. This study includes all partners accounting for at least 1% of Indonesia's reported exports, plus Thailand due to its regional proximity and in case trade Discrepancy trends exhibit any regionally specific pattern.

National trade data for Oman, Saudi Arabia, United Arab Emirates, and Vietnam are not available through the Global Trade Atlas data source, Global Trade Atlas. It is therefore impossible to conduct a bilateral analysis between Indonesia and these four nations. Omitting from the list in Figure two these four nations for which no bilateral data exist, 88.19% of Indonesia's external trade with 11 partners is included in this bilateral analysis. As data for 2020 were not yet fully reported for all nations at the time of this study, 2020 data are excluded from analysis. Sending the study in 2019 has the secondary advantages of excluding the effects of Brexit and Coronavirus, both of which are likely to have caused and to continue to significant market shifts. While these analyses would be highly informative, it is simply too soon to conduct this type of retrospective analysis on such large and evolving processes.

Appendix 2 distills a collection of "Dates for Analysis" from the following national timber import policy profiles. This is a discrete list of moments of enactment, implementation, or enforcement of key national policies with potential to shift bilateral trade and multilateral wood product market dynamics. While these dates would enable a more granular study of impact on trade systems, this research is limited to annual trade data, which will enable us to identify trends over a longer time period but not pinpoint immediate effects.

Australia

Policy:

Illegal Logging Prohibition Act (ILPA) and Illegal Logging Prohibition Regulation

- Enacted 8 November 2012.
- Implemented 30 November 2014 via the Illegal Logging Prohibition Regulation Amendment ("ILPR"). In the two years between enactment and implementation, companies were legally responsible for importing illegal products, but were not required to demonstrate due diligence obligations. The Department of Agriculture and Water published implementation plans in 2014, which included an 18-months grace period for companies to prepare for compliance This "soft-start" period was later extended through January 1, 2018. (Australia Department of Agriculture and Water Resources [ADAWR] 2018; Ludwig 2012).
- Country-Specific Guidelines (CSG) developed with Indonesia beginning 2016, co-signed October 1, 2018 (ADAWR 2018).
- Failure to comply with the ILPA can result in civil fines up to $18,000 or criminal penalties up to 5 years imprisonment (Rose 2017). This research finds no specific record of high-profile enforcement actions with potential to shift market behavior.

Summary:

Australia passed the ILPA and Illegal Logging Prohibition Regulation in 2012, housed within the Department of Agriculture. Prior to ILPA, CITES compliance was the extent of timber import controls, and implementation was regarded as inadequate and inconsistent (Ludwig 2012). ILPA applies a broad definition of illegality, making importers responsible for meeting all legal restrictions of both Australia and the nation of wood product origin.

> "Under Australian law, illegal logging means 'the harvesting of timber in contravention of the laws of the country where the timber is harvested'. This includes a wide range of illegal activities, such as logging of protected species, logging in protected areas, logging with fake or illegal permits, [and] using illegal harvest methods." (Australia Department of Agriculture, Water, and the Environment [ADAWE] 2018).

The ILPA was made effective upon adoption of the Illegal Logging Prohibition Regulation Amendment in 2014, which provided an 18-month phase-in grace period for companies to prepare to be in compliance. The ILPA and ILPR together place a due diligence burden on importing companies, which must perform risk management efforts on specific products. The Australian policy names FSC and PEFC wood product certification as accepted to speed up due diligence processes. In the two years between enactment and implementation, companies were legally responsible for importing illegal products but were not required to demonstrate due diligence obligations. This "soft-start" period was later extended through January 1, 2018. (Australia Department of Agriculture and Water Resources [ADAWR] 2018; Ludwig 2012).

ILPR includes HS Codes 44, 47, 48, and 94. This study is limited to several sub-categories of HS Code 44. ADAWR (2018, p.18) conducted a statutory review of ILPR effectiveness in 2018, which concludes "...it is difficult to clearly attribute any significant impact on the value of imported timber products to the Act's operation" (ADAWR, 2018, p19). Like ADAWR, the current research also encounters limitations to what can be learned from trade data; however, there is evidence to suggest association between ILPR and reduction in risk of illegality, discussed in Sections 5 and 6.

Australia also co-developed Country Specific Guidelines ("CSG"), developed in 2016 and co-signed in 2018 to ensure compliance with the ILPA. This CSG prohibits import of specific HS Codes (4403, 4404, 4406, 4407), and requires documentation proving legality and origin traceability. (ADAWR 2018 p. 5). Together with EU FLEGT policy influenced the establishment of Indonesia's Sistem Verifikasi Legalitas Kayu ("SVLK"), or the Timber Legality Assurance System ("TLAS") (ADAWR 2018, p. 5)

China

Policy:

National Forest Protection Program ("NFPP")

- Enacted 19998.
- Implemented 1999.

Slope Land Conversion Program (“SLCP”)

- Enacted 1998.
- Implemented 1999.

Memorandum of Understanding Concerning Cooperation in Combating Illegal trade of forest Products.

- Signed December 2002.

Domestic Natural Forest Logging Ban

- Enacted 2017.
- Implemented 2017.

National Forest Law Amendment

- Enacted 2019.
- Implementation planned for 2020, but no action or further detail available.

Summary:

China is a prominent importer, manufacturer, and re-exporter of wood products through the history of this study. Previously meeting the majority of domestic needs from national logging, the NFPP and SLCP were enacted with a combination of environmental and economic goals and effectively ended logging in China’s natural forests (Delang & Wang 2013; Ren et al. 2015) and drove massive increases in demand for international supply (Forest Legality Initiative [FLI] 2014; Forest Trends 2020; UN Economic Commission for Europe 2009).

Though Indonesia and China signed a shared Memorandum to combat illegal timber trade, this was not followed with substantive regulation or enforcement (Tacconi et al. 2012). An outright ban on logging China’s state-owned natural forests took effect in 2017, solidifying the primacy of timber imports to supply China’s manufacturing and consumer demand (Hui 2017). China maintains no specific due diligence requirement on imports but ratified the CITES convention in 1981 (FLI 2014). Article 65 of the 2019 amendment to the Forest Law of the People’s Republic of China appears to place responsibility on all importers and exporters to eliminate illegal wood products (China Ministry of Ecology and Environment 2019), but despite 2020 plans to develop implementing regulations and designate authority (Yin 2020; Norman & Saunders 2017), I found no record that these key details had been adopted or implemented.

Norman & Saunders (2017 p.7) reported that “Administrative Measures for Strengthening the Legality of Imported Wood” were under development, and that the private sector and forest product industry associations are in the process of building due diligence capacity and legality verification standards expected to be in line with expected legislation. Barua et al. (2016) find that the rate of potentially illegal Chinese timber imports fell from 2007 - 2016 even while the volume continued to grow, indicating that current voluntary policy guidelines do not sufficiently address the problem due largely to a lack of mandatory checks for illegality in imports.

EU 28

Policy:

EU Forest Law Enforcement Action Plan (“Action Plan”)

- Action Planned published by EU (EUR-Lex, 2003).

EU Forest Law Enforcement, Governance, and Trade Licensing Scheme (“Licensing Scheme”)

- Enacted 20 December 2005 under Council Regulation 2173 / 2005 (EUR-Lex 2005).
- Implementation measured adopted 17 October 2008 (EUR-Lex 2008)
  EU Timber Regulation (“EUTR”).
- Enacted 20 October 2010 under EU Regulation 995 / 2010 (EUR-Lex 2010)

Voluntary Partnership Agreement with Indonesia (“VPA”).

- Entered agreement with Indonesia 30 September 2013 (EU FLEGT Facility [Eu FLEGT] 2018).
- Implementation 15 November 2016 as Indonesia begins EU FLEGT licensing (EU FLEGT 2018).

Summary:

The EU Forest Law Enforcement, Governance, and Trade (“EU FLEGT”) is founded on a 2003 Action Plan and agreement among EU members to “reduce illegal logging by strengthening sustainable and legal forest management, improving governance and promoting trade in legally produced timber.” (EU FLEGT 2020). The “Licensing Scheme” passed in 2005 and implemented in 2008 created a framework for Voluntary Partnership Agreements or VPAs, which enables the EU FLEGT facility to enter negotiations with nations that wish to certify all timber product exports to Europe. VPAs begin with agreements with national partners to develop sector-wide diligence and supply chain transparency, followed by full national licensure. Indonesia entered into VPA with the EU in 2014 and attained full licensure in 2016 (Wibowo et al. 2018; EU FLEGT 2017).

The EU FLEGT Action Plan also laid the groundwork for the 2010 EUTR, which prohibits illegal timber and timber products from entering the European market through legally binding responsibilities on all member states. Member states are “responsible for laying down effective, proportionate and dissuasive penalties and for enforcing the Regulation.” (European Commission [EC] n.d.) It also requires all importing companies to adopt Due Diligence practices which include access to timber product information, risk assessment on operator supply chains, risk mitigation through additional product verification, and record keeping of all suppliers and customers (EC n.d.).

Enforcement of these policies is inherently distributed between EU nations, trade partner nations, and the private sector on both sides of international trade. In particular, the VPA licensure process within the EU FLEGT facility aims to develop entire governance and oversight structures with trade partners, which may be linked to a large variety and number of enforcement actions. For these reasons, this research does not attempt to isolate and cite individual enforcement cases for the purposes of this study. However, there is good evidence to suggest that VPA agreement with Indonesia has led

to an increase in forest law enforcement activities in Indonesia (Nurbaya 2018); and that Europe's VPAs with Indonesia and other trade partners contributed to progress toward VPA-related targets (Cerutti et al. 2020).

India

Policy:

Plant Quarantine Order

- Enacted & Implemented 2003. Specifies which plants and plant products may be imported into India, designates actions required for import, and processes to seek approval for plants and products not specified. Overseen by the Directorate of Plant Protection, Quarantine and Storage.

Summary:

India's demand for primary wood products outstrips domestic supply and is growing quickly (USDA 2019). Imports doubled between 2013 (Fastmarkets RSI 2013) and in the decade before 2020 (Norman & Canby 2020), driven by increasing consumer and manufacturing demand and low levels of domestic timber resources. The Plant Quarantine Order of 2003 explicitly lists which plant species and products may be imported into India, and a process by which to seek to add species to this list (Directorate of Plant Protection 2015). Within this restriction, "wood and wood products can be imported into India without quantitative restriction," (Sood 2019 p.5). While India's Plant Quarantine Order provides legal bases for timber import controls, no regulatory framework specific to ensuring wood product legality is in place and it is likely that unrecorded timber enters and mixes with legal supply with little visibility. (EU FLEGT 2016; Norman & Canby 2020; The Timber Trade Portal [TTP] 2020). This context of growing demand with no timber import policy informs concern that the Indian demand for timber, which is primarily sourced from Southeast Asia and Oceania, could attract illegal products (Vanam 2019).

Wood product imports are also subject to compliance with the national Export Import policy ("EXIM"), but again no regulatory framework exists for timber imports. The EXIM policy was established by the Foreign Trade (Development and Regulation) Act of 1992 (TTP 2020), is updated every 5 years and includes compliance with the CITES listings and requires that importers and exporters obtain permits from relevant agencies for wood products traded internationally (FLI 2014). However, no wood products are restricted by the 2017 update of Import Policy schedule (Director General of Foreign Trade 2015). Norman & Canby (2020 p.5) add, "Certification systems that could verify legality and/or sustainability are also not used widely. Without such systems, there is no guarantee that India's exports of manufactured timber products are verified as legal." The combination of growing demand and limited insight of timber import or export legality may be cause for concern over the legality of both Indian timber imports and value-added wood product exports.

Japan

Policy:

1) “Promotion of Procurement of Environmentally Friendly Goods” (“Green Procurement”) number 100 of 2000.

- Enacted May 2000.
- Implementation expanded to include criteria for wood products (Lopez-Casero 2008; Momii 2020).
- The expansion to wood products is commonly referred to as “Goho Wood”, meaning “legal wood” (Japan Council 2006).

2) Act on Promoting of Distribution and Use of Legally Logged Wood Products.

- Enacted 20 May 2016 as Act no. 48 of 2016 - referred to as the “Clean Wood Act” (US Library of Congress 2016).
- Implementation expanded in May 2017 by adoption of “two ordinances detailing Due Diligence requirements for companies and an institutional framework and mandate for enforcement” Forest Trends (2017). Forest Trends (2017) estimated at the time that “companies are unlikely to be able to register and start implementing the requirements of the legislation until September 2017 at the earliest.”
- No enforcement cases, though the Clean Wood Act provides a mandate for revoking voluntary registration and assessing fines (Li 2019).

Summary:

Goho Wood, while binding, is of relatively narrow scope, pertaining only to public procurement which makes up a small part of total consumption (Japan Ministry of Environment [MOE] 2000; MOE 2017). Goho Wood certification may also displace more rigorous independent sustainable harvest certifications (Momii 2014). The Clean Wood Act passed in 2016 is a more broad but voluntary program for importers to register with the Japanese government for certification of their measures to trade only legally produced wood products. (US Library of Congress 2016). The policy applies to all of the significant wood product categories imported by Japan, includes a 5-year update schedule, and includes penalties for companies making false claims of registration. Self-selection is a limitation of both policies, likely leaving large gaps in the market to which neither Goho Wood nor the Clean Wood Act applies. Momii and Saunders (2020 p.13) see evidence in this shortcoming: “only 397 of the estimated 20,000 businesses eligible for registration had volunteered to do so,” between enactment in 2016 and April 2020.

Note: Indonesia’s history of unsustainable timber harvest is linked to the land clearing that made way for palm oil and pulp and paper industries to arise. Japan is a large source of finance for both timber and palm oil from Indonesia, and there is good evidence the existing policy environment leaves room for ongoing unsustainable practices and clearance of forest lands in supply chains of large companies (Drost et al. 2021).

Malaysia

Policy:

2002 Import ban on Indonesian logs (HS Code 4403)
2003 Import ban on Indonesian square logs over 60 square inches.

Summary:

Each of Malaysia's 13 states creates its own forestry rules within the confines of the National Forestry Act (Malaysia, 1984) and the National Forestry Policy (Malaysia 1978), each of which were updated in the early 1990s (FLI 2013). Illegal timber trade via smuggling, especially along the shared border on Kalimantan, is thought to have been rampant through the early 2000s (Obidzinski et al. 2007; Tacconi et al. 2004; Smith et al. 2003). Obidzinski et al. (2007) find this practice is likely overestimated, and that the greater share of illegality during that period originated in over-harvest on permits issued legally to private companies under poor enforcement of administration and documentation requirements. While timber crossing a border illegally is likely to be detectable through comparing bilateral data between nations, such domestic forms of illegality such as illegal harvest are likely embedded in timber traded but invisible in national trade data. Under international and NGO pressure, the Minister of Primary Industries banned round log imports in 2002 (Chen 2008; Tacconi et al. 2012) and expanded in 2003 to include square log imports larger than 60 square inches (Tacconi et al 2012). I find no further record of Malaysian trade or forestry policy aimed directly at Indonesian timber exports.

Republic of Korea

Policy:

Act on the Sustainable Use of Timbers, No. 11429 (Republic of Korea [ROK] 2012).

- Enacted 21 March 2012.
- No specific implementation timeline or regulatory framework put in place at time of adoption (EU FLEGT 2018)

Partial Amendment to the Act on the Sustainable Use of Timbers, No. 14657 (ROK 2017).

- Enacted 23 May 2017
- Introduced mandatory implementation regulations prohibiting sale of unverified timber in Korea and came into implementation on October 1, 2018.
- Literature review found no documented enforcement cases, though the Act provides a mandate for revoking registration, assessing fines, and imprisonment. (Li 2019)

Summary:

The 2017 amendment prohibits import, distribution, production, and sale of illegal timber, but does not require importers to demonstrate due diligence. The Korean Government introduced "Detailed Standards for Determining the Legality of Imported Timber and Timber Products" (Saunders & Norman 2019 p.1) in August 2018, requiring

compliance by all companies beginning October 2018. The amendment applies to the entire supply chain and are mandatory for all importer of the following products (* denotes products not included in the current study):

- Log (HS4403)
- Sawn timber (HS4407)
- Anti-decay wood (HS4407)
- Fire retardant treated wood (HS4407)
- Laminated wood (HS4407)
- Plywood (HS4412)
- Wood pellets (HS4401-31) *

Saunders & Norman (2019) note that fiberboard & particle board are not included in this list, but that the Korean Forest Service is taking a phased approach to adding product coverage and may be added in the future.

Further, the Korean 2017 amendment uses a more lenient definition of legality than the EUTR and Lacey Act, requiring only that imports comply with legal harvest laws of Korea and the nation of origin, rather than consideration for rights to harvest, land tenure, chain of custody, and illegal sale. (Saunders & Norman 2019; EU FLEGT 2018). In effect, this definition limits possible enforcement actions to a narrower range of issues, as compared with the US and EU policies.

Singapore

Policy:

Singapore's Revised Timber Industry Act of 1985.

Summary:

Singapore's Revised Timber Industry Act (1985) establishes a mandate for timber trade regulation, search and seizure, and prohibition of sales of all products covered in this study. The Act goes into greater detail on timber production within and export out of Singapore, providing little guidance on imports or illegal trade. Through the early 2000s, Singapore was a known hub for timber smuggling, and a key port for transshipment and obscuring timber origins ultimately destined for markets in timber consuming nations (Thornton et al. 2010). During a time of Free Trade proliferation, international agreements had the undesirable effect of obscuring timber supply chains (Environmental Investigation Agency [EIA] 2006), contributing to Singapore's role in maintaining opaque supply chains.

An EU FLEGT Facility (2014) study of ASEAN nations customs practices documents the controls and efforts as customs alignment in Singapore and between ASEAN partners. This study documents that CITES controls are written into Singapore law and that customs agents "...wield extensive enforcement capacity to enforce customs regulations and to support provisions in other legislations, in relation to illegality in trade," (EU FLEGT 2014 p.40). Time and resource constraints did not allow deep investigation into each Partner nation's customs practices, but the power to enforce standards of legality may prove informative for further analysis. Though a signatory of

CITES, Singapore has an inconsistent record of enforcing this commitment, most notable from the 2019 case of transshipment of a huge quality of protected rosewood from Madagascar (EIA 2019). Overall, there is little record of official Singapore timber import policy or coordinated efforts to control illegal logging.

Taiwan

Policy:

Foreign Trade Act (Taiwan Ministry of Economic Affairs [TMEA] 1993)
- 2010 amendment to comply with CITES requirements.

Wildlife Conservation Act (Taiwan Council of Agriculture [TCA] 2013)
- 2014 amended to remain current with updated CITES listings.

Summary:

Because of its largely independent governance, this project treats Taiwan as its own partner in this study for the sake of identifying trade trend differences between Taiwan and mainland China. In the early 1990s, Taiwan outlawed nearly all domestic logging in natural forests (Aspinwall 2018) via The Forestry Act (TCA 2016). However, Taiwan's existing manufacturing capacity remained intact, with nearly all of Taiwan's wood product supply driven to import markets which remain the dominant source of wood products in Taiwan (Huang & Chen 2019; Schloenhardt 2008; Aspinwall 2018).

Taiwan has no wood legality or chain of custody import regulation on record (USDA Foreign Agricultural Service 2020). As a province of China, Taiwan is not a national member of international governing bodies, and therefore is not qualified to sign onto the CITES convention. While in theory Taiwan would fall under China's CITES commitment, in practice it operates more closely to an independent wood product importer without a CITES commitment; despite this ambiguity and potential as a legal trade loophole, Taiwan independently amended regulations to implement CITES listings (Shcloenhardt 2019; Forestry Bureau 2016; TME 1993; TCA 1989). Despite the shift toward import of more processed products, Taiwan remains a large importer of tropical hardwood logs and plywood and Taiwanese companies remain heavily invested in manufacturing companies overseas, raising concern that this contributes to insufficient supply chain oversight (TCA 1989).

Thailand

Policy:

Thailand has no domestic policy specifically regulating illegal timber trade outside of the Voluntary Partnership Agreement (VPA) through the EU FLEGT Facility.
- VPA signed, opening process with the EU September 2013; first negotiations in 2017, second in 2018.
- By entering the VPA process, "Thailand committed to develop a system for assuring the legality of its timber from domestic and imported sources." (EU

FLEGT 2017). However, the details of this system remain yet undetermined as the process is in ongoing negotiations between the two governments.

Summary:

Prior to the VPA, determining legality of Thailand's timber imports consisted of multiple forms of documentation and was not always clear or consistent. Legality is established primarily through customs documentation at the point of entry, often accompanied by Certificates of Origin, a copy of an operator's license, less frequently Phytosanitary certificates, and Bills of Lading for goods arriving overseas. A 2012 report explained both that "It is this combination of documents that means the timber has entered the country legally," and, "However, there is no single unique identifier which enables the timber to be tied unequivocally to the documentation…" (EU FLEGT 2012 p.23).

United States

Policy:

Amendment to the United States Lacey Act Amendment, via the Food, Conservation, and Energy Act of 2008.

- Amended 22 May 2008 to reduce demand and market access for illegal timber and wood products. (USDA 2020b)
- Phased implementation began in 2009, adding specific HS Codes to the enforcement schedule with each phase. Chapter 44, which includes all products covered in this study, was phased in partially in 2009, and expanded in 2015. At the time, USDA acknowledged that companies were unlikely to be able to register and start implementing the requirements of the legislation until September 2017 at the earliest (USDA 2020a). Additional phases continue to add products to the regulated list.

Summary:

The Lacey Act Amendment prohibits "import, export, transport, sale, reception, acquisition, and purchase of any plant taken in violation of the laws of the US, a US State, or relevant foreign laws." (FLI n.d.c p. 3). As of 2009, Lacey holds importers responsible for declaring the sourcing of all wood product HS Codes and complying with all legality requirements applying to an import's supply chain (FLI n.d.c), but not requiring certification of legality. This sets Lacey (and Japan's Goho Wood) apart from the EU Timber Regulation and Australia's ILPR requirements, which further require importers to verify legality of imports (Nurkomariyah 2016). Lacey Amendment violators are subject to criminal and civil penalties regardless of if they are responsible for the entry of illegality into a given shipment of timber imports, and regardless of the importing individual's prior knowledge or 3rd-party certification. (FLI n.d.c). However, compliance is defined somewhat loosely as a "due care" requirement, only that importers show they have taken reasonable measures to identify and control for illegality, leaving the standard for compliance and enforcement rather flexible (Saltzman 2010).

Since the 2008 amendment, the Lacey Act has been used to prosecute companies in several cases. The first Lacey Act enforcement came in a confiscation of three pallets of Peruvian hardwoods imported with “stolen and forged documents” (Hanson 2010; Holt 2010) A second enforcement came in 2012 with a case against Gibson Guitars for two allegations that the company purchased hardwoods harvested illegally from Madagascar and India (Clarke 2012; EU FLEGT Facility 2012b). Lacey was also used to impose fines, a 3-year probation, and public announcement of wrongdoing by a China-based baby furniture maker that imported a large amount of internationally protected hardwood (US Department of Justice [USDOJ] 2009). A final and the most widely known Lacey enforcement resulted in the Department of Justice requiring Lumber Liquidators pay over $13 million in criminal fines for lumber illegally logged in Russia and manufactured into flooring in China (USDOJ 2016). Finally, 24 pallets of illegally harvested Peruvian hardwoods were confiscated by the Department of Homeland Security in 2015 and destroyed in 2017 (USDOJ 2017). These cases indicate the ability and willingness of USDA to enforce compliance with the Lacey Act 2008 Amendment. It may be possible in further analysis to measure the effect of Lacey Act amendment acceptance, implementation, and specific enforcements on trade trends. A 2015 study by Union of Concerned Scientists (2015) found evidence that the American market for illegal wood had shrunk as a result of Lacey implementation, while also finding large quantities of illegal material still are traded and stronger enforcement might lead to a further reduction.

Section 4: Data Overview

The following charts provide a general summary of the data included in this study and help to illustrate several choices made in the process.

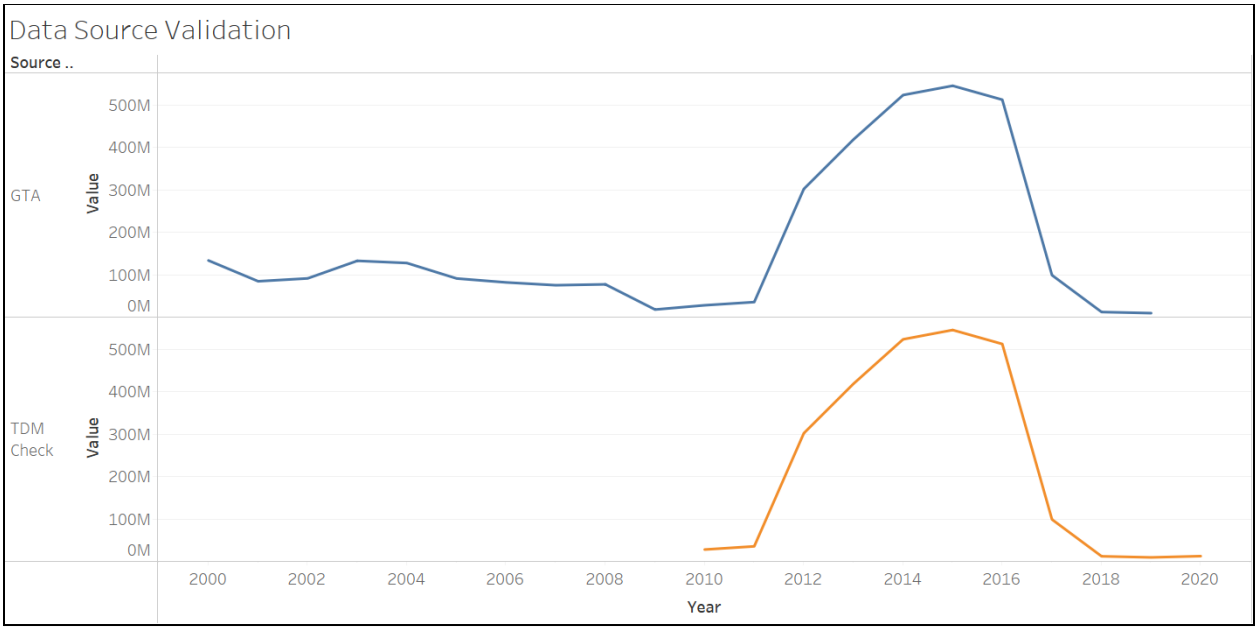
Data Source Reliability

Trade data is inherently challenging, often containing gaps, inconsistencies, and errors within single-nation reporting, with problems multiplying across different national reporting regimes. Data are publicly available through a number of international bodies (Ortiz-Ospina & Beltekian 2018). Literature review shows that FAOSTAT (2020) and UN Comtrade (2021) are the most common sources for data subjected to Discrepancy Analysis, but each of these sources has significant reliability issues. FAOSTAT relies on self-reporting by nations, and despite efforts to increase reliability (FAO 2014) is inevitably subject to great variation in reporting practices that result in large anomalies and likely errors that pose limitations to reliability (Kallio & Solberg 2018). UN Comtrade is the most comprehensive trade database, but is considered less reliable than, for example, OECD Balanced International Merchandise Trade Statistics (n.d.), which is more limited in date range and national coverage (Miao & Fortanier 2017; Ortiz-Ospina & Beltekian 2018).

This research uses privately collected data from Global Trade Atlas (“GTA”) to build side-by-side comparisons of Indonesia’s reported exports and the reported imports of Indonesia’s top wood products trade partners identified in the previous section.

GTA purchases customs data directly from nations. Prior to analysis, I conducted a simple test to validate the Global Trade Atlas data used in this study. Trade Data Monitor ("TDM") also purchases data directly from nations (with a shorter history, back to 2010), and should theoretically match GTA data perfectly. In theory, accessing the same data from two separate sources should produce identical results, and indeed this is the case. Figure 3 shows a side-by-side comparison of GTA and TDM data for Indonesia's reported exports of Hardwood Plywood to China, with identical results from 2010 through 2019. This supports the conclusion that GTA data are a valid representation of the figures supplied by reporting countries included in this story. While this does not mean that data are an accurate representation of actual trade, it does provide a high level of confidence that the data used in this analysis are reliable for assessing real discrepancies in timber trade reporting.

Figure 3: GTA Data Source Validation



This analysis uses data from 2000 through 2019. This date range is in part a constraint: The University of Washington CINTRAFOR lab (2021) has access to GTA data reaching back only as far as 2000, and complete data for 2020 is not yet available for all nations included in the study. Within that constraint, it is also a choice: With the goal to gain insight into the effect of domestic and international trade policies on illegal timber trade originating in Indonesia, this 20-year dataset provides ample baseline data prior to adoption of key trade and forestry policies identified in the National Policies section. It may be possible to add data for 2020 for specific nations if analysis reveals interesting trends or additional country-specific questions.

Custom HS Code Groupings into "Items"

Wood products studied here are aggregated into custom product categories used by the UW CINTRAFOR lab and based on selected groupings of 6-digit-level Harmonized System ("HS Codes"). See Appendix 1 for detailed sorting of the HS Codes into product

categories used in this analysis. Custom categories are referred to here as “C4 Categories”, or by more common names, such as “Hardwood Logs” or “Softwood Plywood”.

Visual Analysis of Preliminary Data

Analysis of the data prior to constructing Discrepancy Scores (discussed in Section 5 and applied in Section 6) is useful to understand the general trends over time, between Indonesia and the eleven Partners studies, and gain an understanding of the magnitude of trade within each Product. This section comprises a preliminary analysis which will inform further visual and statistical analysis. The structure of this “Simple Discrepancy Analysis” establishes the overall structure of analysis in Section 6: First is a view of the data in aggregate, establishing relative importance of each partner and product, and identifying the general trends that take shape over the study period. Second visualizations are developed showing the Simple Discrepancies by both product and partner over the study period. Simple Discrepancies (the difference between paired Export and Import reports of a given product, year, and partnership) are useful only from a high vantage point; the Methods section discusses limitations to analysis of Simple Discrepancies and the adjustments and transformations applied to create a more meaningful metric.

Figure 4 shows the relative magnitude of trade within each product group over time. In later analysis, hardwood and softwood categories are combined into general product groups (Logs, Lumber, Plywood) is dominated by Hardwood. While Lumber and Logs make up a much smaller share of Indonesia’s exports than Plywood, these product groups are important to analysis of timber legality risk as the less-processed products may be subject to less scrutiny and have been known to contain high levels of illegality in Indonesian trade. The products are also inextricably linked, as logs and lumber form the inputs for more highly processed exports such, most notable logs for plywood and lumber for furniture, which not included in this study, but an Indonesian industry of substantial export value (Medyana & Ibadurrohman 2019).

Figure 4: Indonesia Timber Exports Over Study Period

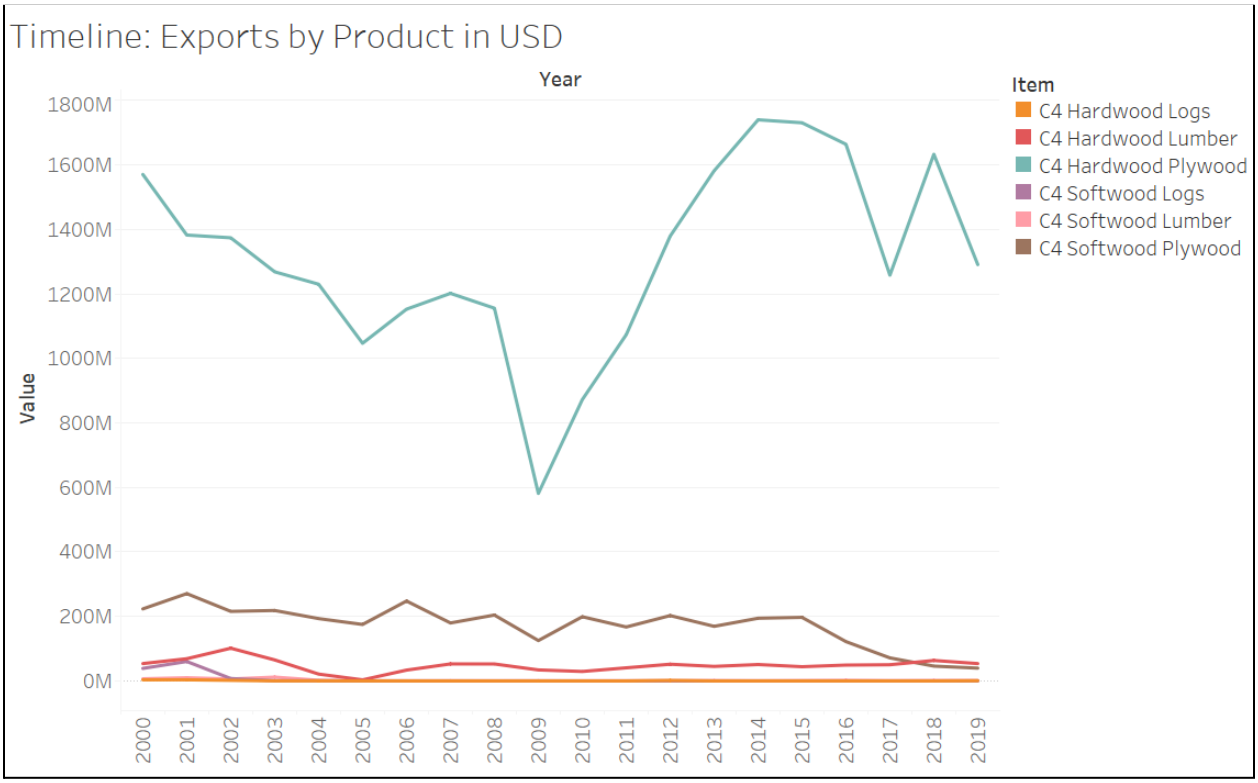


Figure 5 shows the US Dollar value of Indonesia's reported exports, sorted by product category. Hardwood plywood is the clearly dominant product exported. This general trend matches our historical review of Indonesia's wood products industry from Section 2. Lumber accounts for only 3.38% of export reports, but only 21.73% of imports, immediately pointing to large discrepancies and raising the question of what may cause such a difference in reporting. Also notable are the differences in Export and Import reports for Softwood Plywood (1.77% and 6.95%), Hardwood Plywood (88.47% and 72.8%), and Hardwood Logs (0% imports and 2.33% exports). Unfortunately, analysis of these data will not provide a clear-cut answer to the question of *causes* of such discrepancies. Instead, this visualization provides greater insight into the risk of illegality identifiable in discrepancy trends over time and with specific partners. At this stage of analysis, it is sufficient to note the apparent discrepancy in preparation of further analysis.

Figure 5: Percent Value of Timber Export and Import by Product

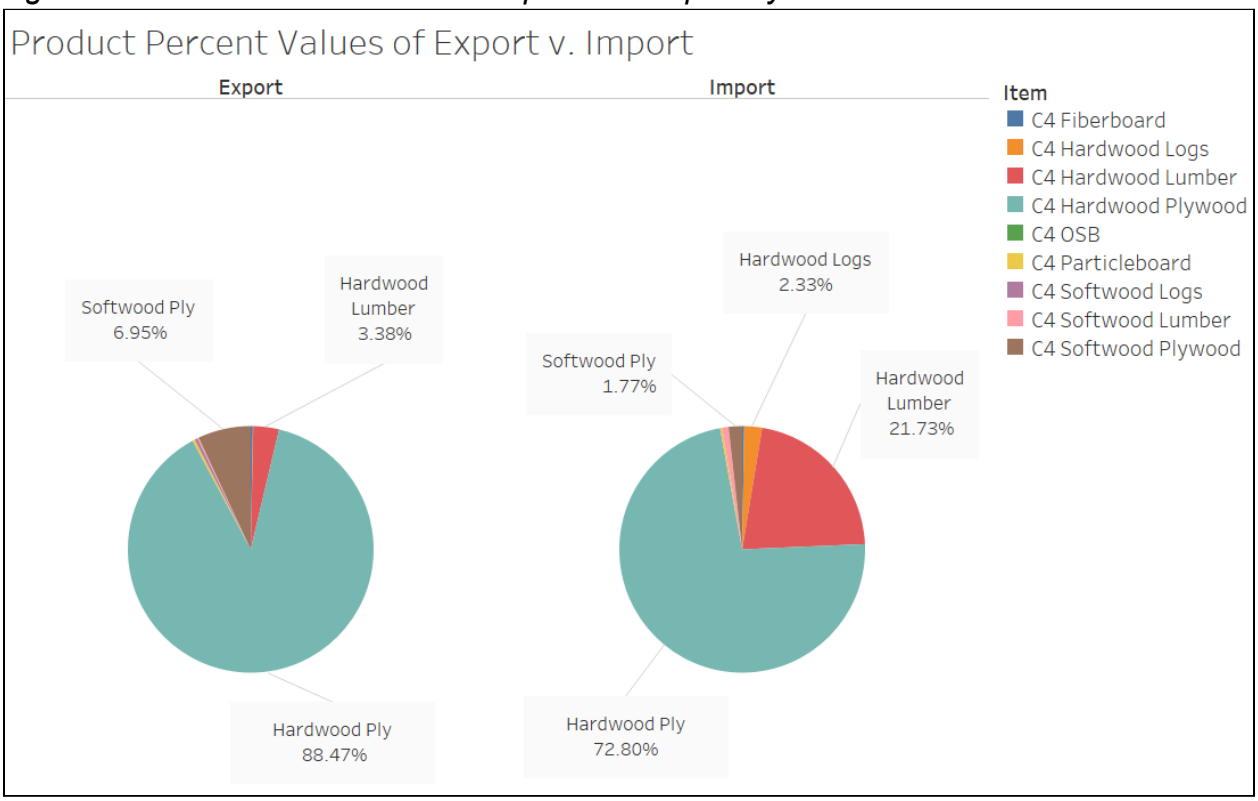


Figure 6 shows the aggregate value of Indonesian Timber Export reports, broken out by Partner. This complements Figure 1, which shows the total percent of exports attributed to each Partner studied, and adds a time dimension, enabling initial identification of notable trends. Most striking is the trend of exports to China, which exhibits a steep rise in 2011-12 and steep fall in 2017-18. This visualization alone raises more questions than it answers, but it is useful to inform later analysis and conclusions. For now, it is sufficient to note the obvious trend, and question whether there could be an association between such events as this precipitous rise-and-fall of trade with China, and the Simple Discrepancies in product reporting identified from Figure 5.

Figure 6: Export Value by Partner over Study Period

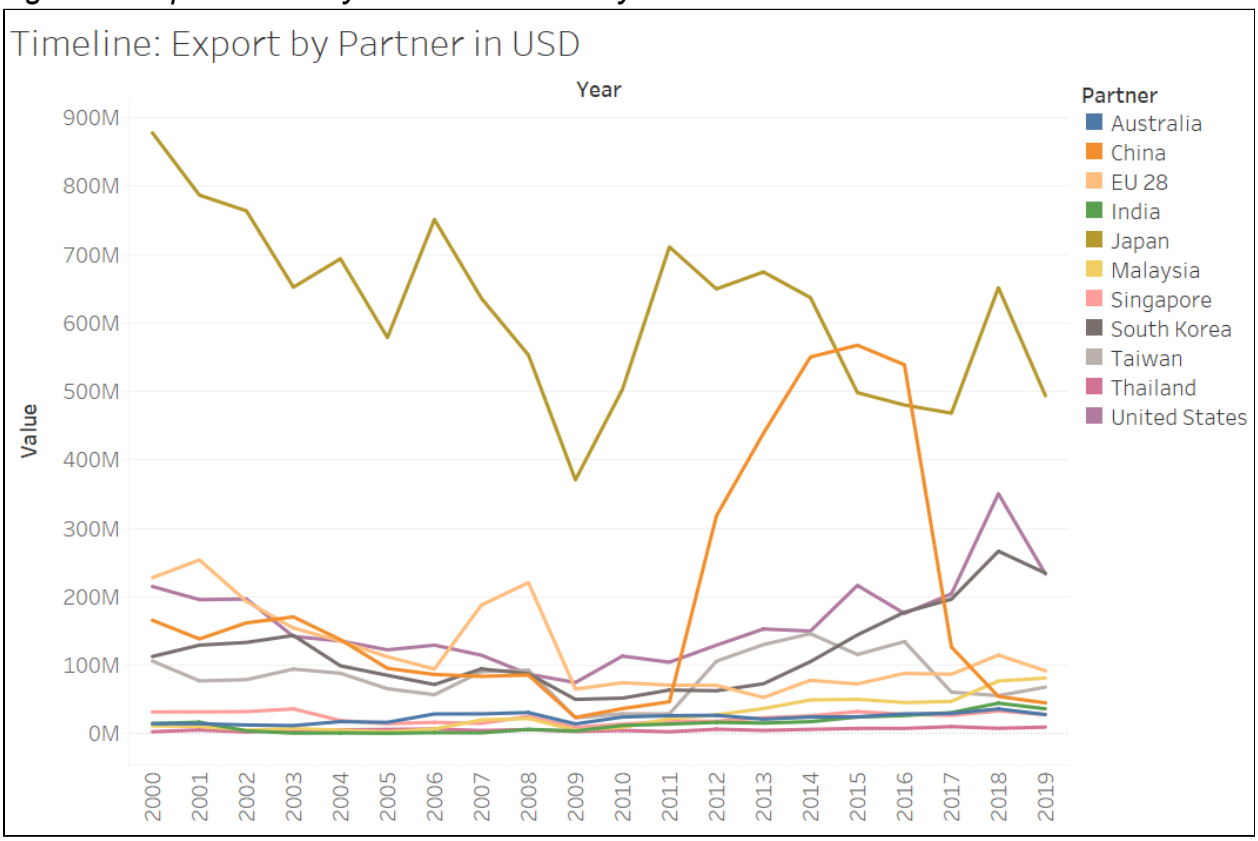


Figure 7 provides a simple view of Indonesia's import-export balance with a total of all partners and wood products categories included in this study. Later analysis will identify more detailed trends in specific bilateral relationships and product categories. At this stage, it bears noting that import value exceeds export value for the entire study period with exceptions in 2008, and 2012-16. This general trend is to be expected, as export reporting typically does not include cost of transportation beyond the exporting nation's borders, while import reporting does account for these costs. Inversions of this trend are only worth noting but not yet explainable. It can also be qualitatively observed that the total magnitude of value discrepancy between imports and exports decreases over the period of the study, but especially between 2000-2007.

Figure 7: Export-Import Value Comparison, Aggregated Products

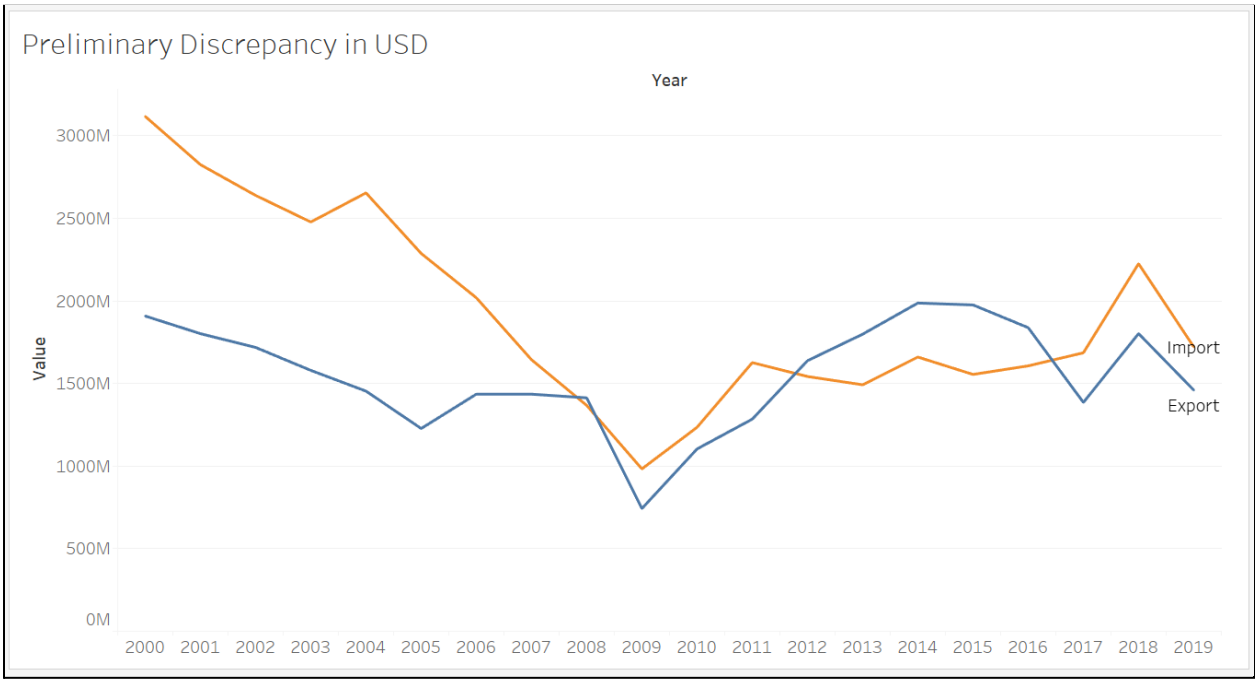
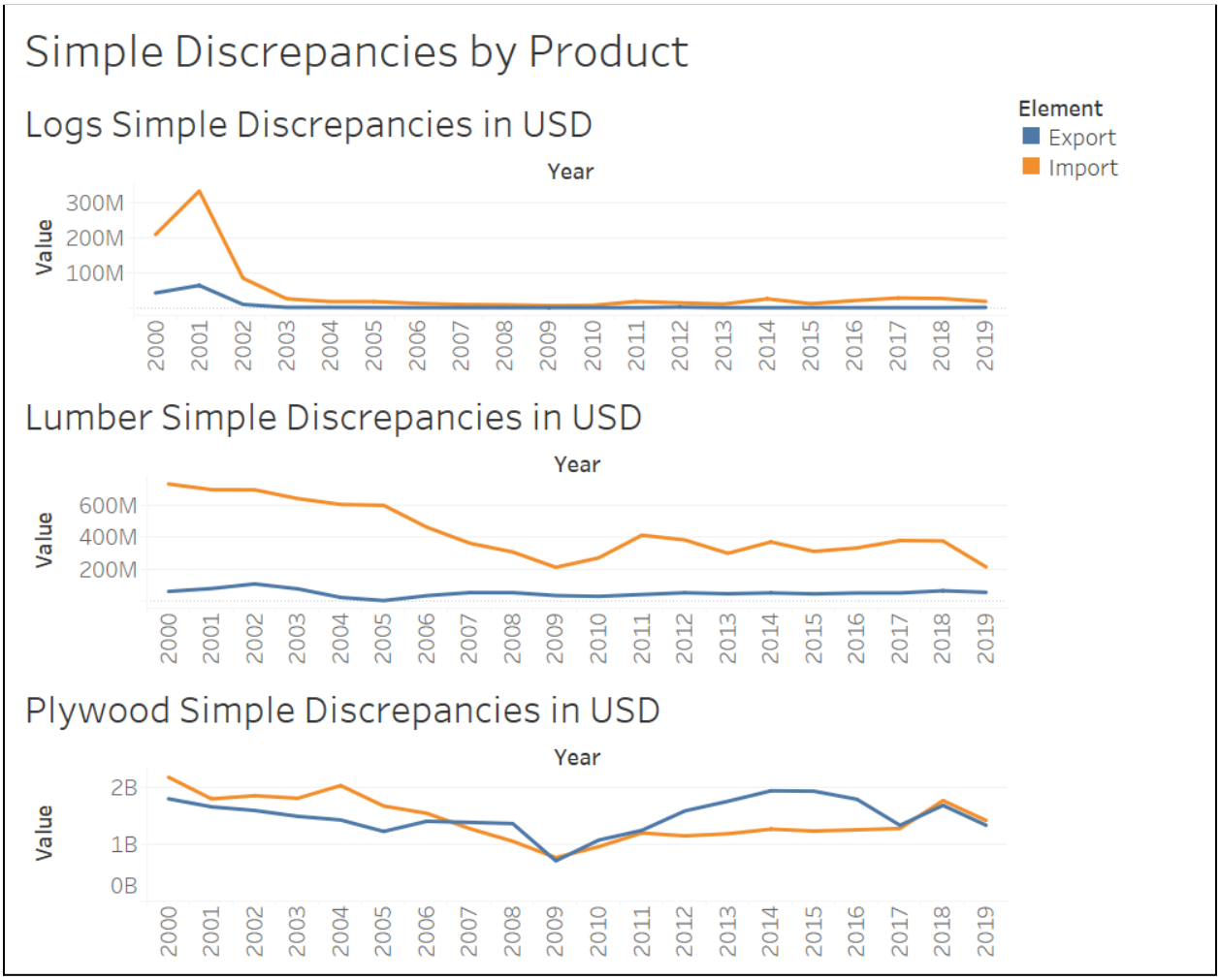


Figure 8 breaks Figure 7 out by Product, revealing that simple discrepancies in Logs spiked through 2001, fell through 2003, and have remained constantly quite low since 2004. Lumber imports are consistently higher than exports throughout the study, though the gap appears to narrow slightly over the study period. Plywood simple discrepancies appear to fluctuate more than either Logs or Lumber and is the only product in which the reported value of exports exceeds imports at any point, which occurs in 2007-08, 2010, and 2012-2016. Most notably, the period from 2012-2016 coincides with the market increase in reported exports to China identified in Figure 6. The Section 6 analysis of Discrepancy Scores returns for further analysis of this observation.

Figure 8: Export-Import Value Comparison, Separated by Product



Now well acquainted with the general contours and patterns of this data, a discussion of Methods follows which explains the challenges of working with trade data for discrepancy analysis, the adjustments applied (and did not apply) to mitigate the biases likely to occur in this data, the transformations made to arrive at a Discrepancy Score used for the full analysis presented here, and a discussion of the visualization and statistical analysis tools applied to develop out analysis and conclusions.

Section 5. Methods

Challenges Using Trade Data to Identify Illegality

While the literature is in broad agreement that discrepancies in bilateral trade reporting must be caused in part by illegal trade activities (McDonald 1985; Obidzinski et al. 2007; Lawson & MacFaul 2010; Fei et al. 2020), seeking insights into illegal trade is inherently difficult as supply chains lack visibility, illegal trade thrives on obscurity, and trade data remain an imperfect measure of real trade (Rozanski & Yeats 1994; Jairo 2004; Chen 2008; Kallio & Solberg 2018; Johnson 2002). No one method to identify and estimate

illegality can be said to provide the best or clearest approach; rather, each method ought to be well understood for its strengths and weaknesses, applied where appropriate, improved whenever possible, and interpreted only within the limitations inherent to the method as applied. Discrepancy analysis entails its own set of specific challenges that can potentially hinder reliable results if misapplied or misunderstood. To that end, it is important to note that this trade data analysis can only possibly give insight into illegality that occurs within international trade, and inevitably does not capture any illegal activity in the timber sector occurring only in domestic trade or not identified somewhere along the supply chain for international trade (McDonald, 1985; Obidzinski et al., 2007; Lawson & MacFaul, 2010).

The following review establishes the range of challenges to employing this method identified in the literature, dividing these into “Sources of Discrepancy,” “Illegal Trade Baseline & Measurement,” and “Other Data Issues.” This included discussion of which discrepancy sources this study does and does not seek to address, explaining here in detail the methodological adjustments and choices made in this study. This review is not exhaustive of all trade data discrepancy studies but is representative of the method as applied primarily to timber trade and as it has developed over several decades. The following describes the transformations made to the data in this study in an effort to control for normal sources of discrepancies. Equations corresponding to each data transformation described here can be found in the Data Preparation section.

Sources of Discrepancy

Many sources contain typologies of discrepancy (see Goetzl 2005; Guo et al. 2009; Eastin & Perez 2003; Lawson & MacFaul 2014; Fei et al. 2020). Rather than attempt to repeat and compare all such lists, the following discusses specific instances in which each of the following challenges is discussed explicitly, or which informs the methods used in this study.

Exchange Rates & Value estimates

Guo (2009), Marini (2018) and Chen (2008) identify exchange rates as a challenge to estimating discrepancy rates by value. Chen (2008) opts to conduct analysis based on volume data because of the difficulty matching relative values between currencies over time. However, Eastin and Perez-Garcia (2003) provide an empirical example that Japanese Yen and US Dollar exchange rate fluctuation contributed only 0.2% of the lumber trade between those countries; and Jairo (2004) estimates that exchange rate fluctuation is unlikely to be a large factor, as nearly all imports & exports are reported in USD; This is holds true for the GTA data used in this study: all value data are reported in US Dollars. Further, the GTA data are less consistent in reporting quantity in cubic meters, rather than kilograms or metric tons. This study assumes that using Dollar value data direct from the data source is preferable to applying exogenous conversion factors, as this may introduce yet another source of error, which runs against the goal of aimed at clarifying the error or variance between bilateral trade reports as far as possible, in order to more accurately interpret illegality. Especially as unit conversion and volume estimation are already sources of error in trade statistics arising directly from

governments, I believed dollar to be the more reliable metric despite the unavoidable complications.

Time / Shipping Lag

The time lag between an export report and its corresponding import report presents a challenge for comparing data presumed to mirror exactly (Hamanaka 2012; Fei 2020). If county A reports an export in time period X, and country B makes an import report for the same shipment in time period X+1, then discrepancy analysis of nations A and B in time period X will inevitably contain reports on different shipments and can therefore be assumed to contain discrepancies due to time lag. This problem is widely acknowledged as a challenge to discrepancy analysis, but the literature is divergent on how to address the issue.

Marini (2018) highlights that improved promptness in reporting could significantly decrease the lag by use of machine-based statistics record keeping. Several Discrepancy studies acknowledge but do not attempt to resolve this particular problem (Eastin & Perez-Garcia, 2003; Vincent, 2004; Chen, 2008; Chang & Peng, 2015) McDonald (1985) applied a lag coefficient in analysis but removed it from the published results after finding it had no significant effect on results. Chen (2008) cites two unpublished studies not located through literature review, Tachibana and Araya (2004), who estimate a 10% or greater lag influence in trade discrepancies; and Goetzl and Wood Resources International (2003), who cite the US Census Bureau as estimating between 0.5% and 1.5%. Both citations are included here; taken together, these two estimates seem best as indications of a possible range and the presence of more uncertainty than clarity on this point. Fei et al. (2020, p. 9) make the most sophisticated attempt in this review to correct with an “adjustment factor” applied to export data.

The lag adjustment factor used in this study makes the same 1-month shipping time assumption as Fei et al. (2020) with some notable changes. While Fei et al. (2020) use quarterly data, this research was limited to accessing annual data. The Fei et al. lag adjustment makes use of an exponential function that has the effect of discounting very large discrepancy values in the data used for this study. Applied to Indonesia trade data, which exhibits many cases of large discrepancies, this adjustment would distort the data. Instead, this study applies a moving average adjustment, shifting Indonesia’s annual export data forward by one-twelfth to approximate a one-month correction in reporting periods.

FOB / CIF

FOB stands for Freight on Board, the total cost of producing, transporting, and up to loading a commodity onto a ship bound for export. Most exporters pay and report using FOB accounting. While exceptions exist, they are few. CIF stands for Cost, Insurance and Freight, which includes the cost of insuring and delivering a shipment to its final purchaser. CIF is an expense added on top of FOB (the customer pays the full cost of production, plus cost of overseas transport and insurance), and is commonly assumed as the standard method for reporting import data. Hiemstra and de Haan (2017) recommended to the UN Statistics Advisory Expert Group that the structure of reporting exports as FOB and imports as CIF be issued international guidance to improve related

data issues. Even in a world where export and import data were completely reliable and consistent, this CIF / FOB difference introduces a predictable, if not perfectly quantified discrepancy into values reported in trade data.

All of the timber trade discrepancy studies reviewed include acknowledgement of this pattern, but none makes an adjustment for FOB-CIF discrepancies. The World Bank (2010) estimates a 10-20% difference but offers no further information on this estimate. Marini et al (2019) explain that the IMF Difference of Trade Statistics ("DOTS") database uses a 6 percent adjustment to estimate missing import values. Miao and Fortanier (2017, p. 23) conduct an analysis of explicit reports of CIF costs for the 16 nations for which data is available, confirming the 6 percent assumption behind the DOTS database, and concluding "...the estimated trade-weighted average CIF-FOB margin in 6.2% for all countries [included in the study] across the period of 1995 to 2014." Given the close alignment between IMF and this empirical analysis, this study applies a 6.2% CIF adjustment to all import values included in the study.

Other Sources of Discrepancy

In addition to the adjustments made to control for certain forms of normal discrepancies, other sources of both normal and possibly illegal discrepancies are widely understood to exist (Rozanksi & Yeats 1994; Goetzl 2005), which this study does not attempt to quantify or control for.

Product misclassification and misreporting varies in reporting at the national and company levels (Chen, 2008; Lawson & MacFaul, 2010; Eastin & Perez-Garcia; Fei et al., 2020). This can result from combined shipment with other products (Eastin & Perez-Garcia 2003); reporting beyond the 6-digit HS Code level at which international codes are harmonized (Tachibana & Araya 2004; Chen 2008); non-reporting or intentional misclassification (Fung et al. 2010; Hamanaka 2012; Lawson & Macfaul 2014); inadequate data collection and validation systems (Goetzl 2005); misclassification of country of origin or destination (McDonald 1985); and simple data entry errors (Chang & Peng 2015)

Product measurement and conversion factors may vary between individual nations, companies, and data compilers (Eastin & Perez-Garcia 2003; Goetzl 2005; Jairo 2007; FAO et al. 2020). Forest product quantity data available through GTA were reported largely in cubic meters, but with a great deal of inconsistency that included metric tons, kilograms, and non-metric weights. In contrast, product values are reported by GTA consistently in US Dollar values. Applying manual conversions to arrive at comparable volume data was too large a risk of biasing already problematic trade data. Instead, this analysis is conducted on dollar values, which at least have been subject to the same standard conversion by the data source.

Transshipment or triangle trade of timber exports through intermediate ports before arriving in final destinations may add legitimate costs more properly understood as separate export costs (Feenstra et al. 1999), administrative errors or poor monitoring, or intentionally fraudulent activity (Goetzl 2005; Jairo 2007). Of specific relevance to this

study, Taiwan, Hong Kong, and Singapore are the largest transshipment hubs in Southeast Asia (Jairo 2007).

In addition to the sources of discrepancies detectable in bilateral trade statistics, a variety of forms of illegality may enter timber products trade, many of which may not ever rise to the level of contributing to trade discrepancies.

Illegal Trade Baseline & Measurement

Illegal timber trade is notoriously difficult to identify, track, and measure, and it is therefore impossible to say how much of which timber products are illicit. Gan et al. (2016, p. 43) identify four general approaches to this problem as "data discrepancies, wood balance analyses, import source analyses, expert surveys and hybrid methods." The following descriptions highlight the relative strengths and weaknesses of existing practices by way of explaining the decision to conduct a study based on trade data discrepancy.

Expert Surveys

This entails developing estimates from the aggregated estimates in survey responses by officials relevant to the trade relationship and product in question. This method is, on the one hand, based in expert perspective and direct experience of perhaps the most informed individuals; and on the other, consists only of estimation and potentially contains bias originating in the very expertise that qualifies one's responses.

Wood Balance Analysis:

Wood balance analysis "compares timber inputs (the sum of production and imports) and outputs (the sum of exports and domestic consumption), comparing this to quantity exported" (Gan, 2016, p. 56); or "compares the legal supply of timber (officially permitted logging and legal imports) with actual consumption (domestic consumption and exports)." (Lawson & MacFaul, 2010, p. 89). In simple form, this looks like:

$$G = (P+I) - (C+X)$$

Where G = quantity (value or volume) of illegal timber, P = domestic production, I = imports, C = domestic consumption, and X = exports. Lawson & MacFaul (2010) warn of limitations to wood balance analysis before undertaking their thorough attempt: No standard method exists, rendering comparison between analyses difficult (though this challenge may be leveled at any of the methods in questions); the method is only capable if identifying illegality in excess of legal harvest, and may miss illegality in production that occurs "before" that threshold is reached; and does not account of illegal timber smuggled out of a producer nation and escaping official reporting.

Import Source Estimation:

Import source analysis entails making an informed estimate of percentage of illegality in producer country timber supply chains, then multiplying total exports by that rate to arrive at a total quantity or value of illegal trade. Import source analysis take the basic form:

$$G = X*R$$

Where G = Illegal Quantity (Dollar or value), X = export quantity (volume or value), and R = estimated rate of illegality. This can be applied to all product trade, or more realistically calculated for individual producer nations, products, trade partners, and policy environments as used by Lawson & MacFaul (2010), Lawson (2010), Hoare (2014), and Barua et al (2016). Lawson & MacFaul (2010) acknowledge both the predominance of this method and its shortcomings, including being used simplistically resulting in attention-grabbing estimates of illegality, and of failing to identify changes over time unless R is thoroughly estimated and updated with regularity. Gan (2016, p. 47) prefers Import Source, as it is anchored in quantifiable import data and "[makes] reference to widely-used illegal logging rates." It must be noted, however, that this method can only be as reliable as the rate estimates themselves, which Gan (2016) also gives reason to question.

Hybrid Techniques:

Hybrid techniques entail a combination of the estimation methods described above. Lawson & MacFaul (2010) provide an example of a thorough process of developing illegality estimates based on expert interviews, trade and enforcement data, policy and implementation trends, and shifting economic dynamics. Hoare (2014) extends this in-depth estimation technique to a broader range of producer, processor, and consumer nations.

Trade Discrepancy Analysis:

Trade data discrepancy analysis, which this study is an example of, entails comparing import and export data to arrive at a discrepancy which may indicate illegal activity somewhere in the trade relationship. A naive model of trade discrepancy would be:

$$G = I - X$$

Where G = quantity (volume or value) of illegality, I = Import quantity, and X = Export quantity. From this, one may extrapolate to a ratio of illegality to imports:

$$\text{Illegal Import Ratio: } R_I = \frac{G}{I}$$

$$\text{Illegal Export Ratio: } R_X = \frac{G}{X}$$

The strengths of data discrepancies are that both import and export values can be obtained from official trade data sources and therefore no estimation is necessary to construct a simple discrepancy model. This enables analysis that is based on officially reported data and quantifiable differences between trade reports from importing and exporting nations. There are significant challenges inherent in trade data that must be overcome to ensure import and export data are comparable. Lawson & MacFaul (2010) also stress that trade data inevitably conceal illegality that takes place in domestic consumption or goes undetected before entering official channels. This point is well

taken and requires that the interpretation of trade discrepancy analysis take into account the likelihood that illegality likely exceeds what is visible in official data. Nevertheless, there is value in the method for its capacity to produce results less reliant on estimation in the other methods. It also has the potential as a method to identify illegality in trade even after specific illegal acts have gone undetected, shining light on trade relationships and products especially susceptible to illegality. Specific challenges to discrepancy analysis are discussed in the following section, addressing also the measures taken to improve the naive model by adjusting for known challenges.

Other Data Issues

Zeros in Trade Data

Bilateral trade data inevitably includes zeros, which can be problematic both for qualitative interpretation and when applying any mathematical manipulations to data for further analysis (Kareem and Kareem 2019). A zero in trade data may represent an actual figure of $0 or zero-volume or weight reported by a nation; or it could indicate a year of non-reporting on a product. This presents a complex interpretive context in which a single zero-value reported has multiple viable, often exclusive, qualitative interpretations, while also posing a problem in quantitative data transformation. The literature is best developed around dealing with when applying logarithmic transformation to trade data containing zeros values (Kareem & Kareem 2019).

This study applies two methods to cope with the presence of zero values, which are plentiful in the raw dataset. First, the Time Lag Adjustment discussed in the previous section applies a rolling average adjustment, which automatically moves one-twelfth of a previous year's export value into the following reporting year. This has the effect of filling in placeholder non-zero values for successive years of $0 reporting following a year with non-zero reporting.

While this moving average renders the data analyzable, it may also be a poor representation of actual trade. If trade occurred but went unreported, the moving average total is unlikely to accurately represent the magnitude of trade for the missing year. If the actual trade reported was $0, the moving average risks masking this report and distorting later analysis which estimates risk of illegality by the severity of discrepancy between import and export. This study seeks to mitigate this bias by truncating data - a method commonly applied even more crudely than that used here, by simply eliminating all observations with a zero value (Kareem & Kareem 2019). After applying the lag adjustment, the 30% of all bilateral observations are truncated for which the sum of import and exporter reports is smallest. This essentially limits the rate of bias introduced by the lag adjustment, which would account for at most 12% of each sum of bilateral observation. It has the secondary advantage of eliminating any observations where both importer and exporter report $0 for a given year and product. Truncation inevitably leads to loss of meaningful information, but discrepancy analysis as a means to identify risk of illegality is appropriately most concerned with larger discrepancies within trade partnerships of greater magnitude.

Data Preparation

This study begins with the raw data introduced above and applies several adjustments and manipulations to render it more meaningfully comparable between import and export reports. The following explains each data manipulation applied to arrive at this analysis.

Units

This study began with both US Dollars (“USD” or “$”) and Cubic Meters (“M3”). Each has its advantages as a metric and can be used together to gain greater insights from the data than possible in isolation. However, analysis relies primarily on US Dollars here, due to difficulties calculating reliable conversion factors for data in different wood products categories reported variously as kilograms, metric tons, and cubic meters. While using US Dollars does present the challenge of fluctuating exchange rates over time, it will be possible to refer back to point-in-time exchange rates as necessary to develop detailed analysis.

Elements and Partners

This study develops analysis of the discrepancies between reported exports and reported imports. This is referred to in the data and charts as the “Element” and referred to here simply as “Import” or “Export”. This means that when exports are being discussed for this analysis, this study refers to the data reported directly by the exporter, Indonesia; discussion of imports refers to the data reported by importing nations. For this reason, and somewhat confoundingly, the terms “Reporter” and “Partner” are used as relative to the Element being analyzed. For example, when discussing exports, the Reporter is Indonesia and all others are Partners; but when discussing imports, the relevant nation or group is the Reporter, and Indonesia the partner. This is due in part to the nature of the study which aims to learn whether and what discrepant patterns exist in Indonesia’s wood products data reporting as compared with that of its trade partners. This study compares two perspectives of a one-way trade flow. The study therefore includes export data for Indonesia and import data for all other included nations and national groups.

Items

This study includes six categories of Indonesian primary timber products (See the “Data Overview” section and Appendix 1 for a discussion of these product groups):

- C4 Hardwood Logs
- C4 Hardwood Lumber
- C4 Hardwood Plywood
- C4 Softwood Logs
- C4 Softwood Lumber
- C4 Softwood Plywood

Softwood and hardwood categories are combined into Logs, Lumber, and Plywood for Analysis in Section 6.

Lag adjustment

A moving average is applied to shift import values by one month to more closely control for 1-month shipping time lag. This equation has the added benefit of interpolating at least partial import data into years where importing nations had $0 reports, rendering later discrepancy ratio calculations possible. The Lag Adjusted Value (LAV) equation is:

$$LAV = \left(Year\ 1\ value \times \frac{11}{12}\right) + \left(Year\ 2\ value \times \frac{1}{12}\right)$$

CIF/FOB adjustment

Lag-adjusted Import values are divided by a CIF adjustment factor of 1.062, as explained in “FOB / CIF Adjustment” section. This decreases imports values by the estimated 6.2% discrepancy due to imports reporting of Cost, Insurance, and Freight rather than Freight on Board. The Adjusted Partner Value (APV) equation is:

$$APV = \frac{LAV}{1.062}$$

Simple Discrepancy

A Simple Discrepancy (SD) is derived by subtracting an APV from a Reporter Value (RV, or export) for a specific product, year, and partner, or finding the difference between exports and adjusted imports.

$$SD = (RV\ of\ product\ X\ in\ year\ Y\ to\ partner\ Z) - \left(APV\ of\ product\ X\ in\ year\ Y\ from\ reporter\ Q\ \right)$$

Discrepancy Ratio

Then a Discrepancy Rate (DR) is calculated by dividing the simple discrepancy by the average of import and export values. This has two important aspects. First, when a specific instance of mirrored trade contains a zero-value reported by either a Reporter or a Partner, averaging the two effectively works around the zero-value challenge discussed previously. Second, dividing by the average of imports + exports reflects the assumption that a discrepancy constitutes an aggregate of errors in reporting, and that the “real” value of trade exists somewhere between the two reports. Having controlled where possible for import-side reporting discrepancies, this study assumes an average of imports and exports is the best approximate of “real” trade with which to build a discrepancy ratio. Third, this ratio returns a set of values, all between 2 and -2, rendering the widely variant Simple Discrepancy, more readily analyzable. This has the effect of constraining further analysis to interpretations of rate rather than magnitude, enabling us to approach questions of discrepancy rates relative to volume of trade for each product and partner. The equation for Discrepancy Rate is:

$$DR = \frac{SD}{\frac{(RV+APV)}{2}}$$

Discrepancy Score

Discrepancy Rates are then weighted by sorting Simple Discrepancies into deciles and applying a multiplication factor to the Discrepancy Rates to arrive at weighted Discrepancy Scores (DS). This improves on the DR by weighting large value discrepancies more heavily than small value discrepancies. To create this score, the absolute value of Simple Discrepancies is divided into ten deciles, each containing an equal number of observations and ranked 0-9 from smallest to largest absolute value (DEC). This is then multiplied the Discrepancy Rate of each observation by the Decile, resulting in a weighted Discrepancy Score.

$$DS = DR \times DEC$$

Data Non-Linearity

Initial testing for heteroskedasticity gave reason to question this assumption. Figure 6 Charts each Discrepancy Rates for each Importer inclusive of all Items, compared to a theoretical linear model and shaded area denoting the 95% confidence range. Discrepancy data for each partner exhibit a similar roughly S-shaped pattern where the preponderance of observations in the “middle” of the data lie relatively closer to the linear model as compared to the tail ends of the data, indicating a very high density of outliers at the extremes of our discrepancy ratio values. This pattern appears sufficiently and consistently divergent from the linear model to question whether the assumption of linearity is appropriate. Quantile-Quantile plots (qq plot) are used to verify this observation. Figure 9 shows qqplots broken out by Partner, and Figure 10 shows the data divided by Product. Discrepancy rates sorted by both Partner and Product exhibit a similar pattern of deviation from linearity.

Figure 9: National Discrepancy Rates compared to Linear Model

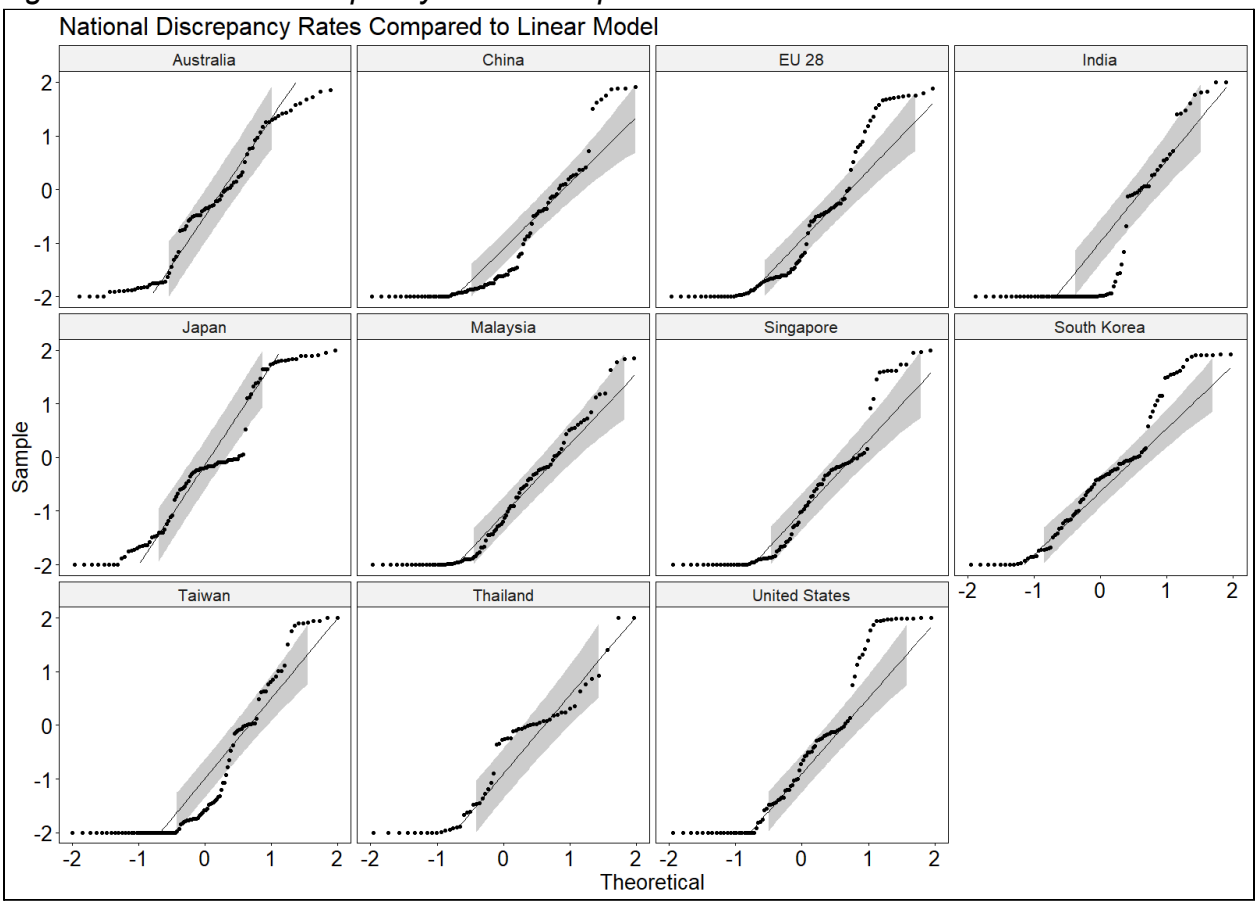
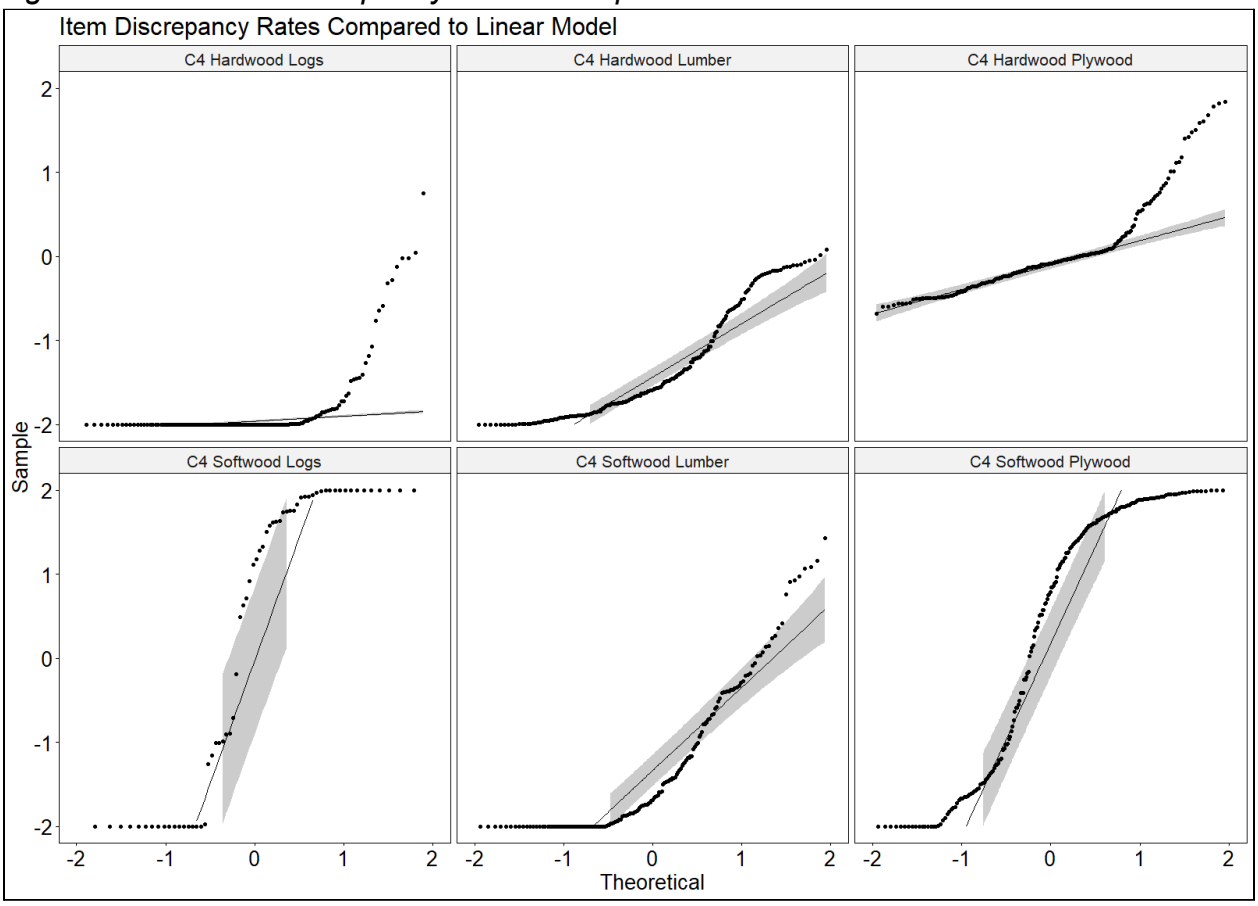


Figure 10: Product Discrepancy Rates Compared to Linear Model

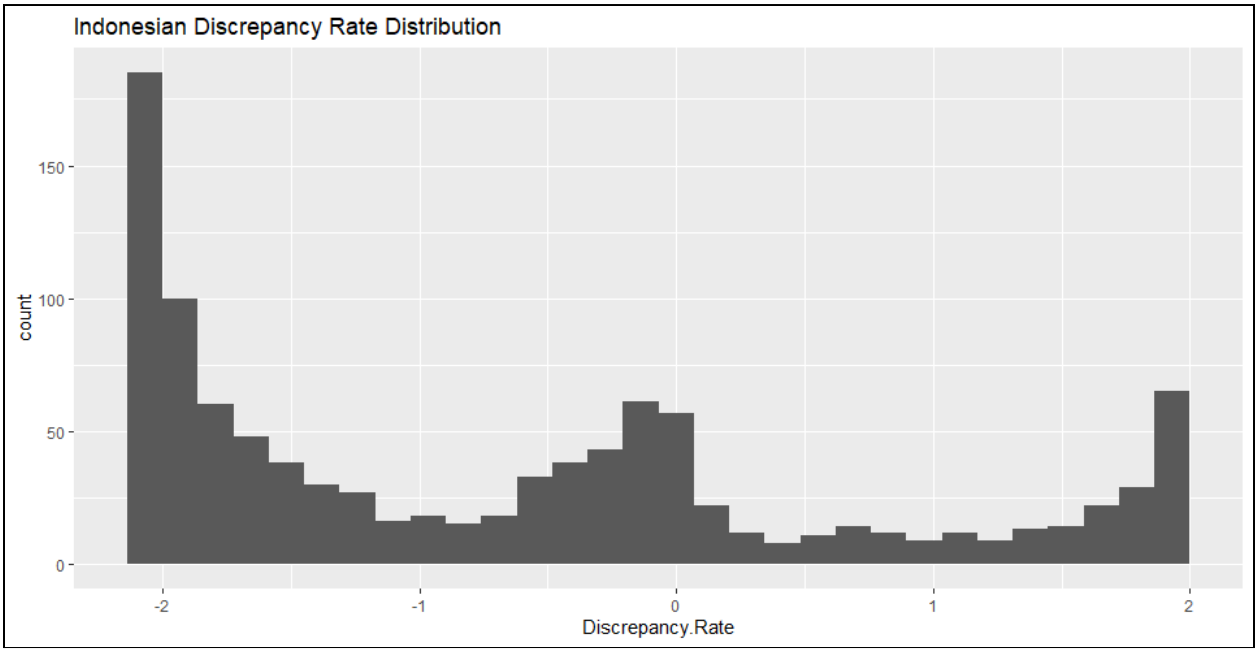


This pattern may be expected as a result of data cleaning and Discrepancy Ratio equation. Rows of data were removed where both exporter and importer recorded $0 trade but kept all observations where at least the importer or exporter reported a trade value, as this data may provide meaningful insight. Applying a ratio equation then transforms any instance of unilateral reporting into a -2 or +2 Discrepancy Ratio, concentrating all such observations toward the poles of this data. This is not altogether undesirable for the purposes of this study, which aims to detect where national reporting is most extreme. This should enable clear identification in cases of systematic non-reporting by specific partners or items, or a combination. It does, however, give cause to question how the “shape” (linearity) of our Discrepancy Ratio data pulls the raw data away from its assumed normality.

It is quite likely that some of this non-normality is due to outlier results, especially arising from instances where one trade partner reports a 0 value in the same product and year that the other partner reports any positive value. As noted above, this results in a discrepancy rate of -2 or +2, as can be seen in Figures 9 and 10. These outliers, however, cannot be presumed irrelevant or merely anomalous for this data. From a pure

data perspective, the repetition of extreme values undermines the assumption that outliers are anomalous or so rare as to unrealistically skew the data set. Interpreted within the context of trade, these patterns may be exactly the trends that most clearly show risk of illegal timber in supply chains. Regardless of interpretation, Figure 11 confirms the outside presence of extreme Discrepancy Rate data points, and a trimodal distribution with clusters around 0 discrepancy, and the extremes of +2 or -2 and skewed toward -2.

Figure 11: Distribution of Discrepancy Rates

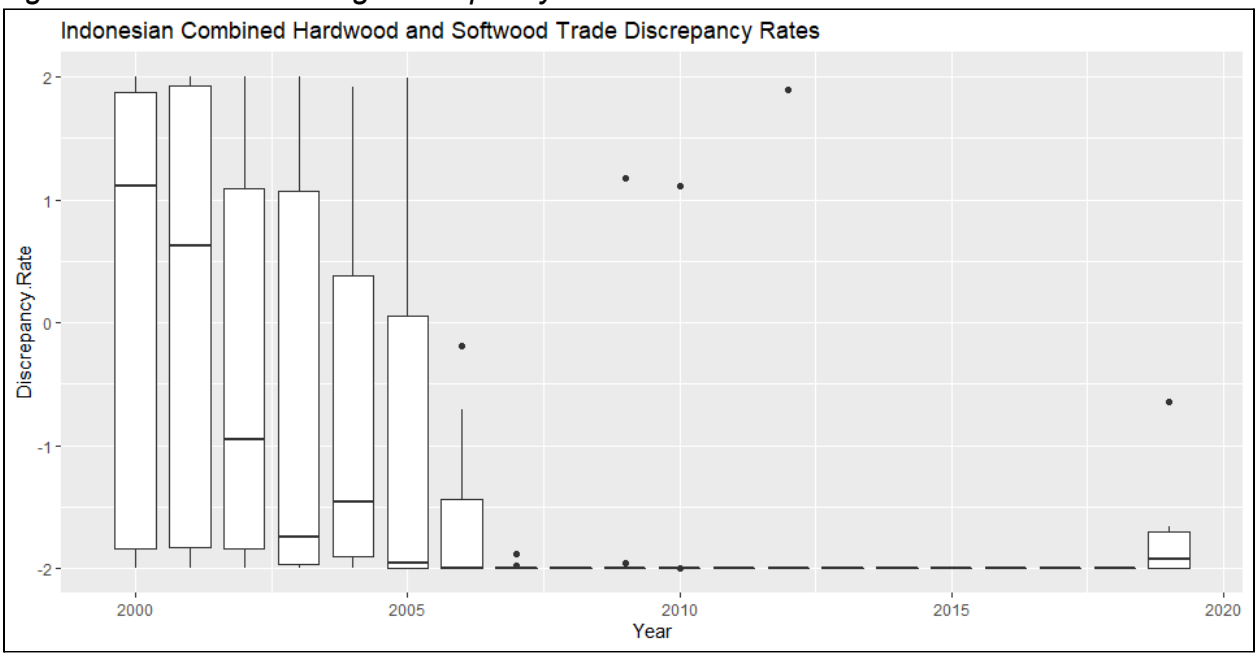


Indonesia's log export ban presents a simple case to illustrate the importance of the extremes in the data set. First, a hypothetical scenario: Country A exports logs to Country B with relatively normality prior to instituting a complete log export ban. After the ban takes effect, Country A reports 0 log exports to B, but B continues to report some amount of log imports from A. From this pattern, a pattern of -2 reports would likely arise and might thus infer that the log export ban is not completely effective and therefore that log exports from A to B are at high risk of illegality. Simply removing the outliers from consideration risks undermining the strength of analysis or even entirely missing a potentially important trend. Thus, it is more appropriate to consider these data as not normally distributed rather than normally distributed with outliers.

Intuition from this hypothetical scenario appears to hold true when applied to the actual case of Indonesia's log exports after the reinstatement of an outright log export ban in 2001, followed by strict enforcement measures in 2005-6. Despite too short a "before" time period to quantitatively analyze the effect of the Ban, Figure 12 illustrates the qualitative trends expected from the hypothetical. It does appear that discrepancy rates became more negative after the 2001 ban until 2006, indicating a trend of underreporting by Indonesia compared to partners. Then the discrepancies rates flatline at -2 from 2007 through 2019 after increased enforcement in 2005-6 (Obidzinski et al.,

2007; Prasetyo, 2012), resulting from consistent 0 reports by Indonesia compared to positive reports by partners. The implication here is that Indonesia reports no log exports in accordance with the ban, but that these reports should be regarded with suspicion given consistent reports that partners receive at least some log imports from Indonesia.

Figure 12: Indonesian Log Discrepancy Rates 2000-2019



While Discrepancy Rates appear non-normally distributed, the Discrepancy Score data (a weighted Discrepancy Rate) appear closer to normal, as shown in Figure 13. However, Figure 14 contradicts the intuition from Figure 13, showing that Discrepancy Score data are not normally distributed. Despite data non-normality, this study applies ANOVA and T-Tests, both of which are relatively robust to deviations from normality.

Figure 13: Distribution of Discrepancy Scores

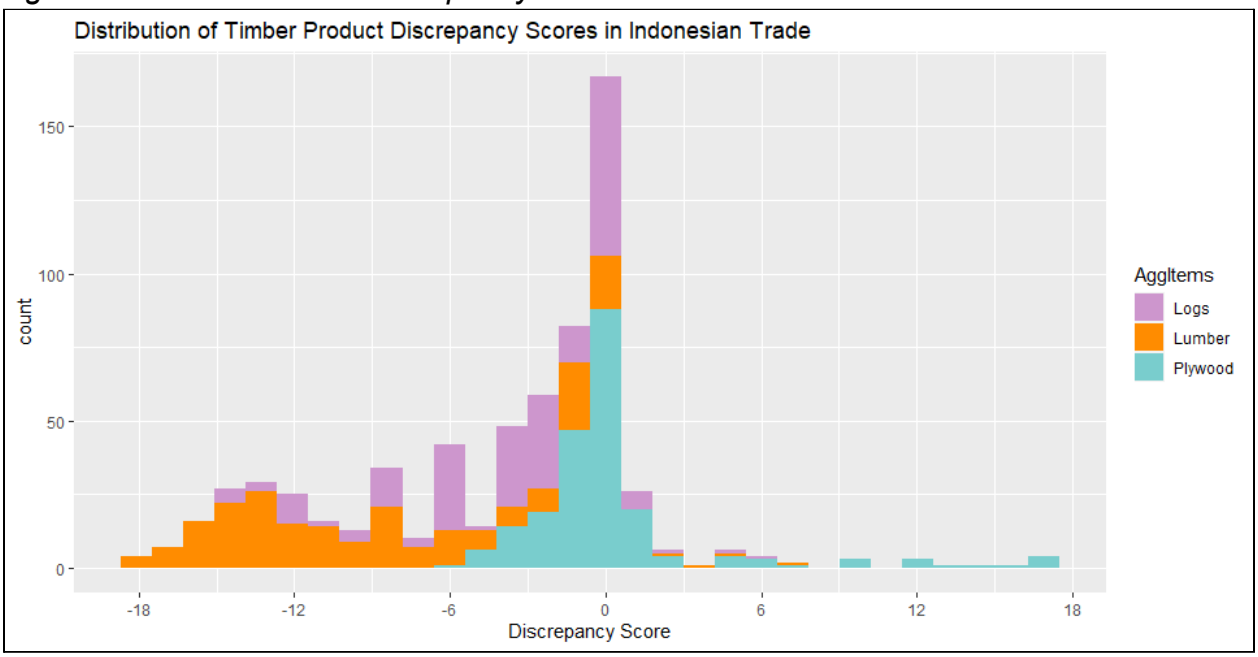
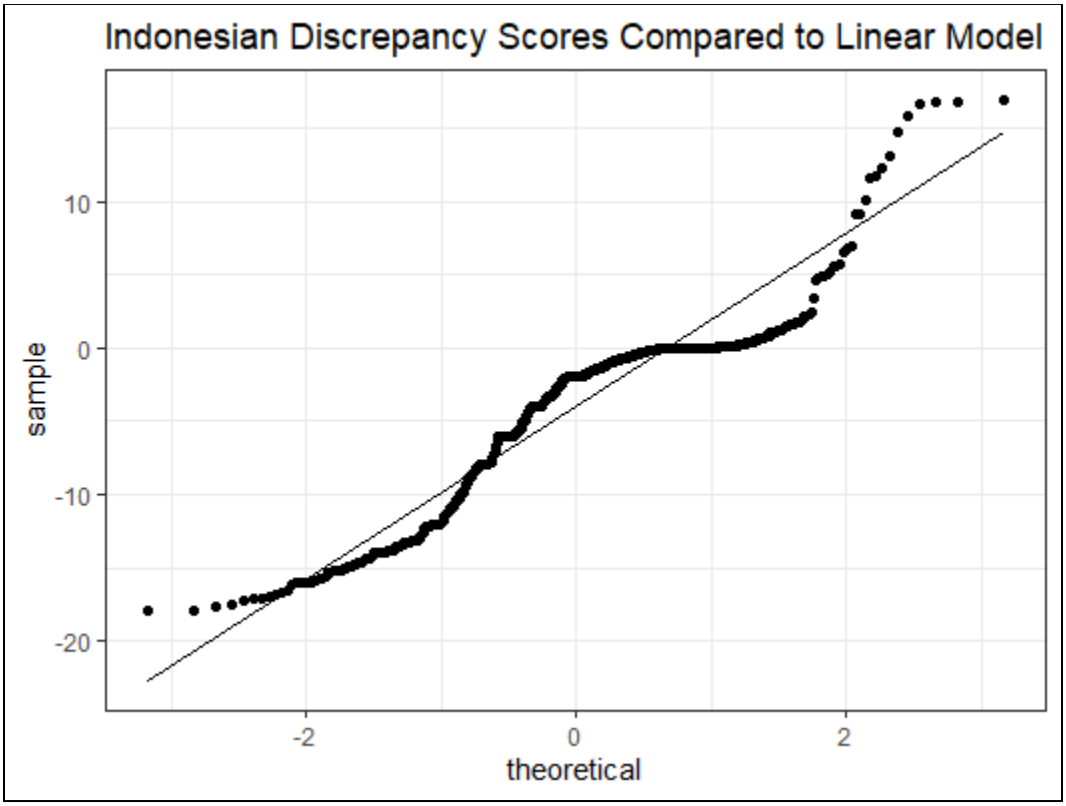


Figure 14: Discrepancy Scores Compared to Linear Model



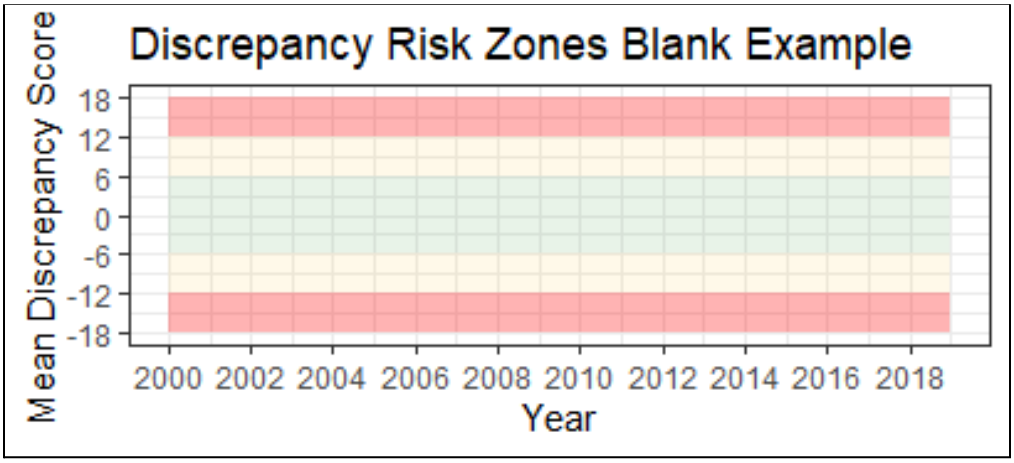
Visualizations

Four “Views” or grouped sets of visualizations are developed to enable deeper insights into the data. This begins at a general level of visual analysis, with each successive series drilling further into the detailed and specific relationship between Discrepancy Scores and Partners, Products, and Time Periods. View 1 is a relatively simple comparison of Indonesia’s reported Exports compared to its Discrepancy Scores, indicating the importance a partner plays as a timber product exporter relative to the Discrepancies in that partnership. View 2 is an “Aggregate View” of mean discrepancy scores across all Partner and products. View 3 is a “Product View”, showing mean Discrepancy Scores broken out by Product. View 4 is a “Partner View”, which shows Product-specific mean Discrepancy Scores for each Partner. View 4 also shows a selection of the policy events collected in Appendix 2, enabling the construction of Policy Periods described below and used in the Statistical Testing section.

Risk Zones

In Discrepancy Score visualizations, we apply an approximate “risk level” indicator, which divides the entire Discrepancy Score range into three colored zones representing their magnitude of Discrepancy Score, or the distance from a score of 0. As Scores deviate further from 0, we regard them as of higher risk of illegality, regardless of negativity or positivity (which represent whether a given export report by Indonesia falls above or below its mirrored Partner import report). Therefore, the Zones are best understood as indicating the range of absolute distance from Zero Discrepancy Scores. Zone 1 is colored green to indicate low risk of illegal activity and ranges from negative six to positive six. Zone 2 is colored yellow to indicate moderate risk, and ranges from negative six to negative twelve and positive six to positive twelve. Zone 3 is colored red, indicating high risk and ranges from negative 12 to negative eighteen, and positive twelve to positive eighteen. These zones are not scaled to the data, meaning that 33% of the data do not fall into each zone. Rather, the zones are based on the static range of discrepancy scores and indicate the approximate density of scores within that zone. Figure 15 is a blank example of the Risk Zones as used in the Analysis section, Views 2 and 3. For partner-specific visualizations used in View 4 and in the Statistical Testing section, the same Zones are used but find it more illustrative to color the bars themselves rather than background colors.

Figure 15: Discrepancy Risk Zones Example



Policy Periods

Our statistical analysis primarily consists of comparing mean discrepancy scores across time periods, trade partners, and product categories. The product categories and partners are givens, while the time periods are constructed for the purposes of this analysis. In creating the time period Indonesia's policy timeline is primary, which places secondary importance on policy timelines for trade partners as well as visual interpretation of the Discrepancy Scores trends. The policy timelines are inevitably coarse, intended to enable analysis of larger trends, rather than pinpoint moments at which trends shift. The imprecision is due to a combination of factors: annual data forces the decision of when to say a policy takes effect; in some cases, it was possible to locate specific enforcement or implementation dates (see section 2), but even given a precise date, the interaction between data reporting lags and policy timelines is difficult to estimate.

Given this ambiguity, this research makes several assumptions and apply them as consistently as possible. I assume that Indonesia's domestic and international policies should be considered as primary, and partners' policies as secondary - this means that the policy periods are designed according to Indonesia's policies as a first consideration. When statistical tests are run on importing nations' policies, this is stated clearly in the accompanying analysis. Except where a specific implementation date is known, the policy's adoption or enactment date is used as the appropriate cutoff period. Implementation is considered more likely to result in a reduction of Discrepancy Scores than enactment or adoption. Take for example Australia's Illegal Logging Prohibition Act (ILPA) passed in 2012 and the Illegal Logging Prohibition Regulation (ILPR) of 2014: because the ILPR puts the ILPA into effect, 2014 is taken a better cut-off for a policy period. Finally, literature and qualitative interpretation of Discrepancy Score trends inform which policies appear most closely associated with notable shifts.

Period 1 runs from 2000-2005, informed primarily by then-Indonesian President Yudhoyano's enforcement mandate discussed in Section 1. This is also somewhat congruous with Malaysia's import bans on logs and sawn wood in 2002 and 2003 respectively and Japan's Goho Wood addition to its sustainable procurement policy.

Period 2 runs from 2006-2008, the period of enforcement following Yudhoyano's mandate. There is a notable decline in Discrepancy Scores among many Importing nations during this period, most visible in the Lumber Discrepancy Scores figures in Appendix 3, followed by a rebound in discrepancy scores in the several years following 2008. The global recession beginning in the USA and spreading globally in the following years provides further subjective reason to break this period in 2008. This timeline is also roughly aligned with the US Lacey Act amendment passed in 2008 and updated to include wood HS Codes in 2009.

Period 3 runs from 2009 - 2013. Indonesia issued regulations enforcing its Timber Legality Assurance System (TLAS, or SVLK in Bahasa) in 2013 as part of its VPA agreement with the EU signed the same year and active in 2014. It is also approximately synchronized with Korea's 2012 Act on the Sustainable Use of Timbers, and Australia's 2014 Illegal Logging Prohibition Regulation.

Period 4 runs from 2014 - 2019, given the absence of significant new timber trade policy in Indonesia. While trade partner nations do enact, implement, or amend policies during this period, those changes are mostly ancillary to existing policies (e.g., Korea's 2018 Partial Amendment to the Act on Sustainable Use of Timbers, which put in place mandatory implementing regulations). I judge that these importer-nation policies are best addressed in nation-specific analysis.

Statistical Test Series

Building from the Views analysis of this Discrepancy Scores data, 6 statistical "Test Series" are conducted in approximately the same fashion as the Views: beginning with general tests at aggregate levels of Partners and Products and developing detailed tests at progressively finer levels of analysis. Each of these tests is constructed around the Policy Periods described above, or around specific Partner policy events.

Test Series 1: Null Hypothesis "There is no difference in mean Discrepancy Scores with a given Partner across the four Periods." and an Alternate Hypothesis: "Mean Discrepancy Scores with Partners differ significantly between the four Periods." To test this, a One-Way ANOVA on the effect of Time Period on Mean Discrepancy Scores for each Partner and with aggregated Products is conducted. A Tukey Honestly Significant Difference Tests ("Tukey HSD" or "Tukey Test") to identify the specific Periods which have a significantly different mean Discrepancy Score for a given partner is then conducted for each Partner that shows a significant P-Value from the ANOVA test.

Test Series 2: Null Hypothesis: "There is no difference in Mean Discrepancy Score in each product category and across all Periods." The Alternate Hypothesis is: "Mean

Discrepancy Scores differ in each product category between Periods." A one-way ANOVA test is used to compare mean Discrepancy Scores in each Period for each Product, keeping Partners aggregated. Finally, a Tukey Test is conducted to identify which specific periods return significantly different results.

Test Series 3: The Null Hypothesis is: "There is no difference in mean Lumber Discrepancy Scores with each Partner between Periods." The Alternate Hypothesis is: "Mean Lumber Discrepancy Scores with each partner differ between Periods." The dataset is narrowed to Lumber, and test for differences between Periods for each Partner using one-way ANOVA, followed by a Tukey Test to identify which periods are significantly different for given Partners.

Test Series 4: The Null Hypothesis is: "There is no difference in mean Discrepancy Scores for Indonesian Lumber exports before and after a given policy event." The Alternate Hypothesis is: "Indonesia's mean Lumber Discrepancy Scores differ significantly before and after a given policy." Two-tailed t-tests are conducted on Indonesia's mean Lumber Discrepancy Scores before and after both its 2005 Enforcement Order, and 2013 implementation of the SVLK policy.

Test Series 5: The Null Hypothesis is: "There is no difference in mean Lumber Discrepancy Scores Between Indonesia and a Given Partner before and after that Partner's Policy Event." The Alternate Hypothesis is: "Mean Lumber Discrepancy Scores between Indonesia and a given partner differ before and after that Partner's Policy Events." Two-sided t-test with unequal variance on mean Discrepancy Scores between Indonesia and each partner that has adopted a specific timber import policy during the study period test this hypothesis. Two tests are run for Japan and Korea, each of which adopted two specific policies during the study period.

Test Series 6: The Null Hypothesis is: "There is no difference in mean Lumber Discrepancy Scores between Indonesia and a given Partner with no import policy before and after Indonesian Policy Events." The Alternate Hypothesis is: "Mean Lumber Discrepancy Scores between Indonesia and a given Partner with no import policy differs before and after Indonesian Policy Events." Two-sided t-tests with unequal variance on mean Discrepancy Scores between Indonesia and each partner that does not have a timber import policy to test this hypothesis. The first tests for significant differences before and after the 2005 Enforcement order; the second tests before and after SVLK implementation.

Section 6. Analysis: Indonesian Timber Trade Discrepancies 2000 - 2019

Two widely accepted assumptions, established in Section 1, frame the following analysis: That illegality in timber trade contributes to Import and Export reporting discrepancies between partner nations; and that Indonesian timber trade in particular

continues to include some amount of illegal product. The three research questions are: 1) How effective are national policies at curbing Indonesian illegal timber trade? 2) Which specific nations exhibit the highest risk of illegal timber imports from Indonesia? 3) How effective is Discrepancy Analysis for identifying illegality in timber supply chains?

To approach these questions, this analysis begins with a series of Discrepancy Score visualizations to identify the high-level trends in this data. These visualizations are constructed prior to statistical analysis in order to inform testing hypotheses and identify appropriate statistical tests. This entails the development of several “Views” of the data, which reveal Discrepancy Score dynamics in the entire system (View 1), within each Product category (View 3), and specific to each Partner (View 3). The Product-specific visualizations include significant policy events for Indonesia, and the Partner-specific visualizations include Policy events for both Indonesia and the relevant Partner. These views inform hypotheses and statistical testing decisions including the Time Periods used to compare periods of this study with one another. Following from the Views, six statistical “Test Series” are developed to evaluate the significance of trends identified from qualitative interpretation of the previous visualizations.

Discrepancies Visualization

This analysis of Discrepancy Scores visualization proceeds in four steps, each of which enables intermediate observations and conclusions as well as informs statistical testing in the following section. View 1 compares Indonesia’s Export values for each Product and Partner, establishing grounds for a general intuition of the share of discrepancies compared to the magnitude of trade and informing test Series 5 and 6. View 2 displays mean Discrepancy Scores for the aggregate of all Partners and all Products, followed by average Discrepancy Scores in each Product category, informing Test Series 1 and 2. View 3 provides Discrepancy Scores with Partners aggregated and Products broken out separately, informing the decision to limit statistical testing to Lumber in Test Series 3-6. View 4 shows each specific Partner’s Discrepancy Score data in all three Product categories side-by-side and includes relevant Policy events for partners also detailed in Appendix 2 and the “National Partner Policies” section. Each nation’s Scores are observed individually to enable detailed analysis of Partner dynamics within Product categories, informing the Policy Periods used for statistical testing and enabling interpretation of results from each Test Series.

In all of the following visualizations, the green, yellow, and red coloring of bars or shaded regions indicate respectively the lowest, middle, and highest 33% ranges of the full Discrepancy Score scale, which is a weighted average with a range of negative 18 to positive 18. Negative scores indicate underreporting by Indonesia compared to its Partners; positive scores indicate Indonesian overreporting. Additional to the visualizations discussed in detail here, Appendix 3 provides panels for each combination of Partner and Product with significant Indonesian Policy events annotated as vertical bars.

View 1: Shares of Export Value Compared to Discrepancy Scores

Figure 16 is a side-by-side comparison of reported exports and reported imports, sorted by Item and with all Partners aggregated. It is important to note that the data are narrowed here to include only Logs, Lumber, and Plywood categories, and combined all Softwoods and Hardwoods for each of these categories. Several high-level trends stand out: Hardwood plywood accounts for 84.5% of exports but 72.8% of imports; Hardwood lumber accounts for 3.12% of exports but 21.7% of imports; and Hardwood logs account for 0% of exports but 2.33% imports. At this stage, it is only possible to note trends and pose questions to inform further analysis. As noted in the previous historical section, Indonesia has maintained some form of log export ban since 2001. While the 2.33% difference between export and import of hardwood logs may seem of trivial magnitude, the policy context gives reason to pay special attention to this product category for signs of underreporting of log exports, as this may indicate illegal trade.

Figure 16: Product Percent of Export Values and Discrepancy Scores

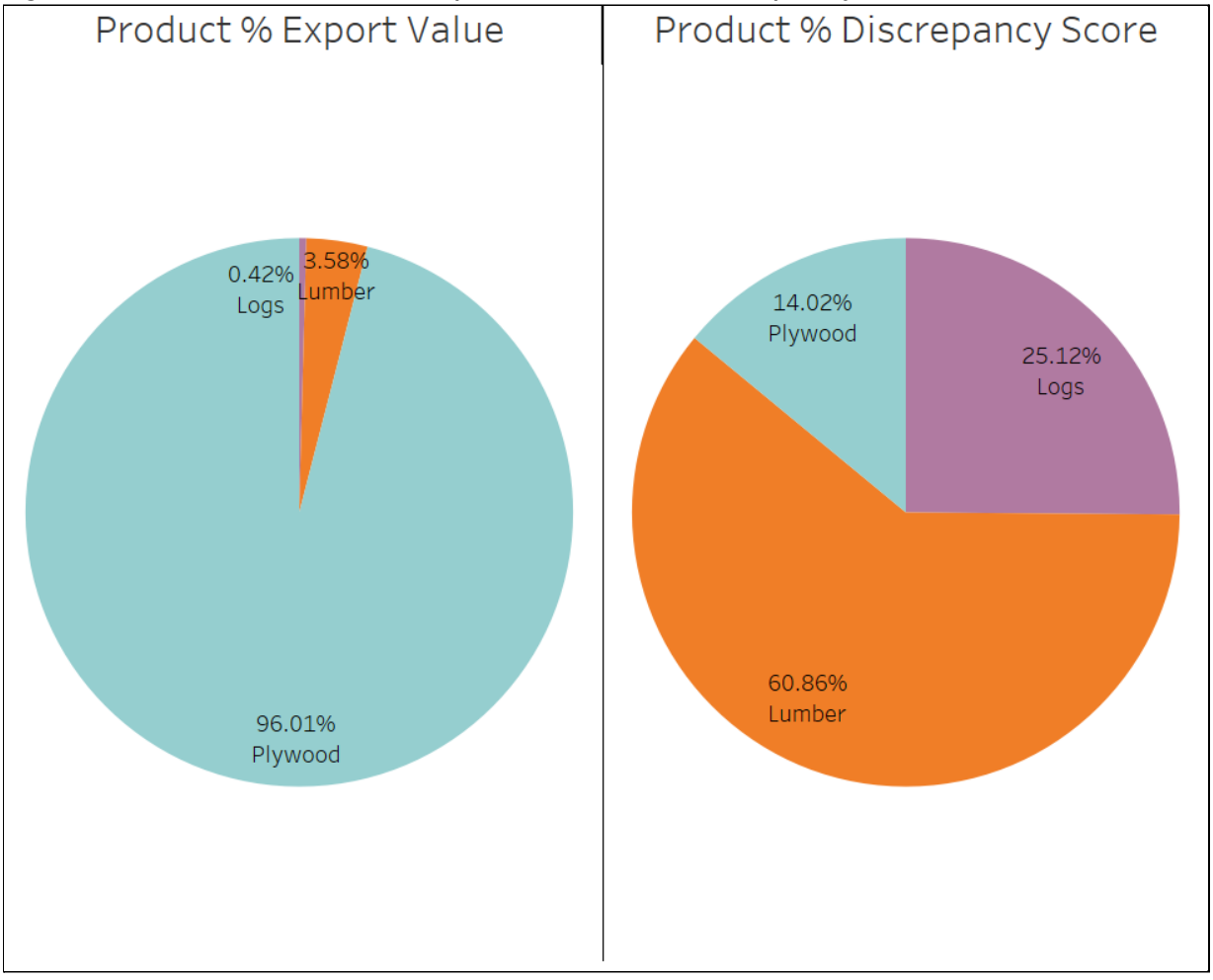


Figure 17 shows a comparison between the percent of timber exports Indonesia reports to each of the Partners studied, alongside the percentage of Discrepancy Scores that

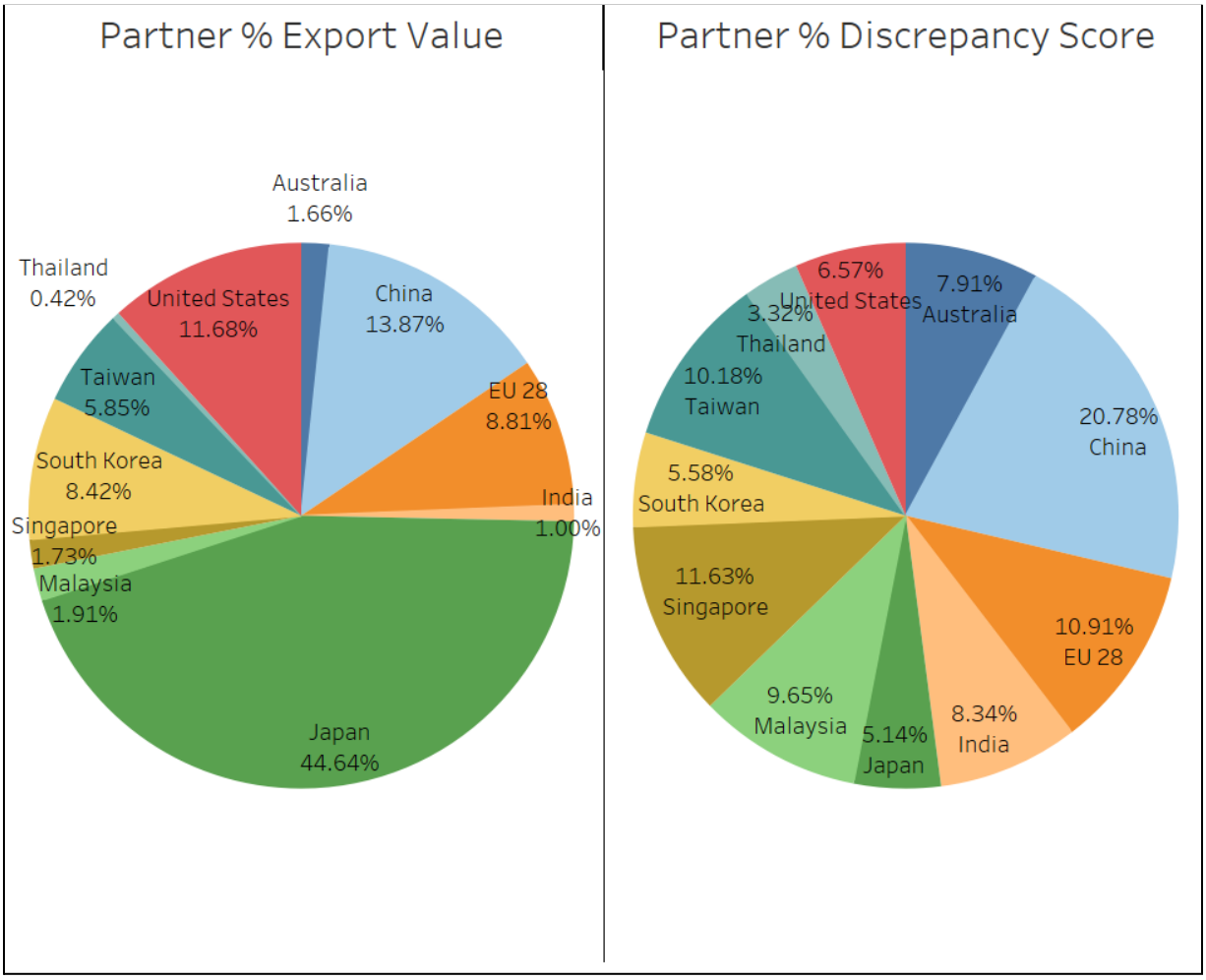
each of those trade partnerships represents. At a crude level, this comparison indicates the scale of discrepancy relative to the importance of a trade partnership.

Only three nations account for a larger percentage of export value than Discrepancy Scores, with Japan at 44.6% of trade and only 5.1% of Discrepancy Scores; the United States 11.7% trade and 6.6% Discrepancies; and Korea 8.4% of trade and 5.6% of Discrepancies. This may be reason to think that each of these partnerships is of little concern from a standpoint of illegal timber imports, especially as each has enacted and implemented timber import policies and regulations. This intuition is supported by the reverse trend: Partners with no timber import policy that account for a larger share of Discrepancy Scores than of export value. Those nations include China (13.9% trade, 20.8% discrepancy), India (1% trade, 8.3% Discrepancy), Malaysia (1.9% trade, 9.7% Discrepancy), Singapore (1.7% trade, 11.6% Discrepancy), Taiwan (5.9% trade, 10.2% Discrepancy), and Thailand (0.4% trade, 3.3% Discrepancy). The only exceptions to this trend are Australia (1.7% trade, 7.9% Discrepancy) and the European Union (8.8% trade, 10.9% Discrepancy). However, these are two large exceptions as both Australia and the EU have enacted robust policies with Indonesia-specific agreements. Therefore, this high-level comparison does not yet fully support the notion that the simple existence of timber import policy leads to a reduction in Discrepancy Scores and illegality.

A regional pattern is observable: Each of the Partners for whom Discrepancy Scores are out of proportion with Export Values is a regional neighbor, with the European Union the only exception. Though a clear explanation is not supported here, but it is plausible that this is due to bias in the uniform application of CIF/FOB adjustments discussed in the Methods section. It may also be that the combination of less-regulated importers (China, India, Singapore, Thailand), and less-developed nations play a part in the effectiveness of illegal timber trade controls (the EU and Australia are both exceptions to this theory).

The following Views dissect the data more finely and enable discussion of trends over time that lend greater nuance to the following analysis.

Figure 17: Partner Percent of Export Values and Discrepancy Scores



View 1 Summary Observations and Conclusions

Shares of Discrepancy Scores are proportionately lower than shares of export value among several Partnerships where the importer has a timber import policy (Japan, United States, Korea). Two notable exceptions to this trend are Australia and the EU, each of which has a timber import policy but accounts for a proportionately greater share of Discrepancies than export value.

Shares of Discrepancy Scores are proportionately higher than shares of export value among several Partnerships where the importer has no timber import policy (China, India, Malaysia, Singapore, Taiwan, and Thailand). There are no exceptions to this trend in the data.

Regional neighbors exhibit a share of Discrepancy Score disproportionate to their share of Export Value.

Logs and Lumber each account for a disproportionately large share of Discrepancy Scores compared to their relative Export Value; the opposite is true for Plywood.

Therefore, Plywood trade appears of least concern, Logs of significant risk in the context of Indonesia's export ban; and Lumber of greatest risk.

View 2: Aggregated Discrepancy Scores

Figure 18 presents the average discrepancy scores for each year in the study, with all Partners and Products aggregated. Most immediately obvious is the consistently negative Discrepancy Scores, which may range from -18 to 18, but at the aggregated level are negative for the entire study period. Indonesia consistently underreports the value of its timber exports compared to Partners' import reporting. While this pattern may be expected in simple differences between raw import and export reports (Goetzl 2005; Ortiz-Ospina & Beltekian 2018), this trend of underreporting persists even after the adjustments applied to correct for shipping lag time and freight and insurance costs. The CIF cost is the only normal source of discrepancy which should be expected to bias data toward the negative due to importers accounting for costs not typically included in export declarations (Hiemstra & de Haan 2017; Marini et al. 2019). This indicates that Indonesia's underreporting compared to national Partners is due to factors other than this structural CIF / FOB imbalance.

Despite the consistently negative Discrepancy Scores, there is also a trend of scores normalizing over the study period: more extreme scores appear to be most common toward the beginning of the study, peaking in 2005 and declining after that. This peak corresponds to the year that Indonesia's President Yudhoyano mandated stricter enforcement of illegality protections in domestic supply chains after several years of increased timber seizures, which Lawson & MacFaul (2014) conjecture may contribute to the decline following 2005. The 2005 "Enforcement Order" is included in further analysis, using 2005 as a cutoff between Policy Periods to test for significance differences in Discrepancies in specific product groups and partnerships before and after policy implementation.

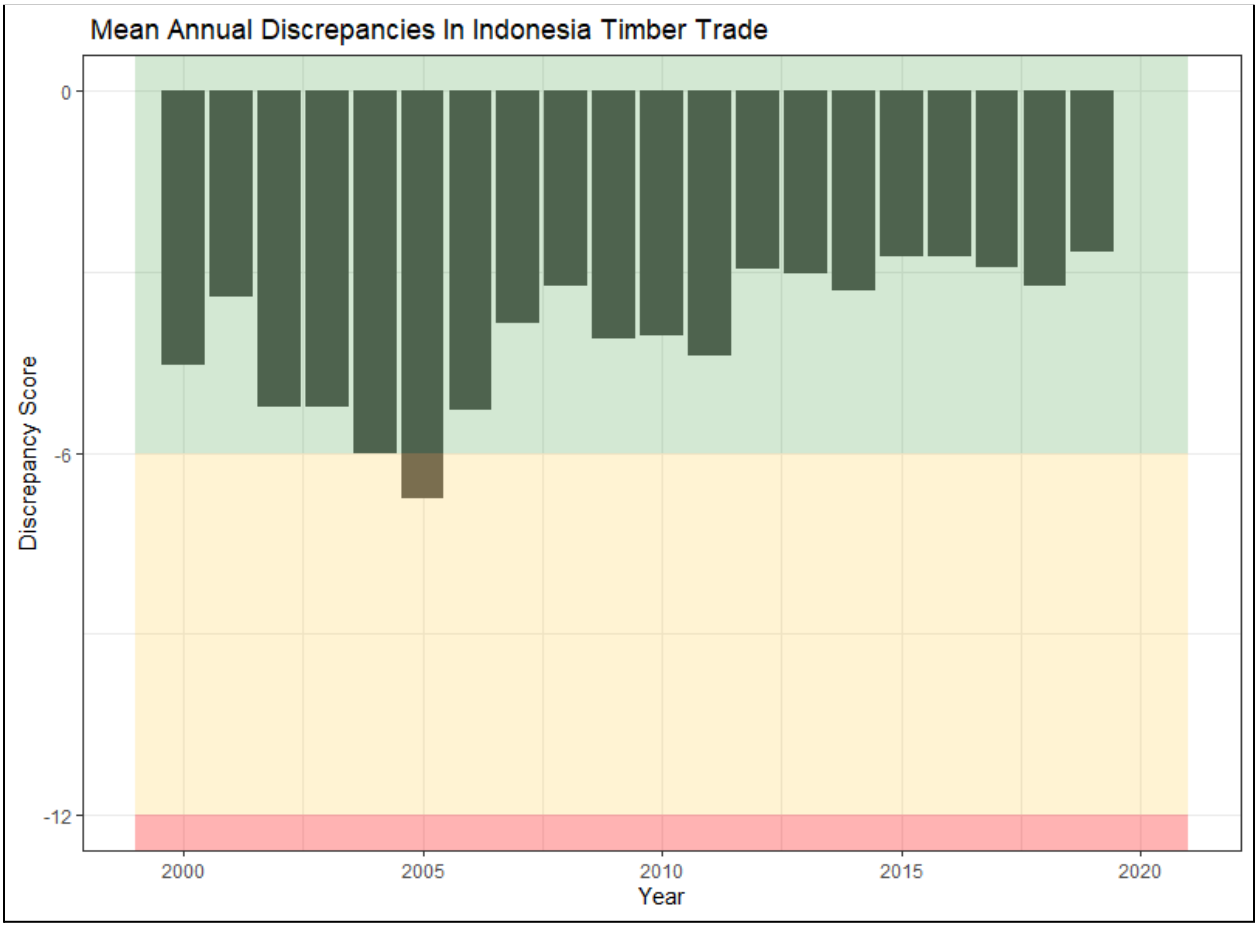
A final trend of note at this aggregate level of visualization is that total level of discrepancy does not appear particularly concerning, dipping into the yellow middle-risk third of Discrepancy Scores only in 2004-05. As shown in View 3, product-specific Discrepancy Score visualizations indicate the aggregate analysis may mask important trends and developments at the Product and Partner levels.

View 2 Summary Observations and Conclusions

There is a decline in the extremity of Discrepancy Scores over time, but from this View alone are unable to draw conclusions as to the significance, magnitude, and possible Policy associations with this trend.

From the Aggregate View alone, it is clear that Indonesia routinely underreports Timber exports compared to import reports from its top timber trade partners.

Figure 18: Mean Annual Discrepancy Scores of Aggregated Timber Products



View 3: Products

Figure 19 disaggregates products to present mean Discrepancy Scores for separate product categories. It is immediately clear that separating the products provides for a much more nuanced interpretation. This pattern holds true for dissecting the data by Partners and each combination of Partners and Products.

Log Discrepancy Scores appear relatively constant over the study period, showing a consistently negative but low risk mean Discrepancy Score between -3 to -6, indicating consistent underreporting of relatively low magnitude. A slight trend in normalizing discrepancy scores is visible, with a peak in 2003. Given Indonesia's Log Export ban since 2001, one would expect both that log exports would be quite small and therefore of little value, and that the Discrepancy Rate (see Methods section for this equation) would be at the extreme of -2, since a $0 report from Indonesia compared to any positive dollar amount reported by a Partner would result in a 100% Discrepancy Rate. Therefore, Discrepancy Rates for Indonesian log exports, though extreme, are weighted relatively lightly due to the small mean value of Logs traded, resulting in a consistent negative but low risk trend in Discrepancy Scores. The case of log Discrepancy Scores serves to inform the intuition in interpreting these trends and validates the broad

purpose of developing a Discrepancy Score: to identify those Products and Partners at greatest risk of the greatest value of illegality.

Lumber exhibits the most extreme mean Discrepancy Scores at the aggregated Partner level, informing an conclusion that the risk of illegality is greater in Indonesian Lumber Trade than in either Logs or Plywood. The following Partner View section shows that Lumber trade exhibits the largest Discrepancy Scores with each individual partner. This informs the decision to emphasize Lumber Discrepancy Scores more heavily than Logs or plywood in the following analysis.

The 2004 banning of lumber exports and 2005 enforcement crackdown appear to match the steep decline in Lumber discrepancy scores from 2005 through the end of the study. This Product View informs the decision to use the 2005 Enforcement Order as the cutoff between Policy Periods. 2005 is the most realistic turning point in Lumber Discrepancy Scores because the enforcement order was a broader order to improve implementation of the bans and timber illegality law enforcement prevention measures. This may be debated since executive action may be shorter lived and more easily overturned by successive orders. For this reason, further results around the Enforcement Order (and other policies) are interpreted loosely - as indicators rather than sole causes of changing trends. It would be nearly impossible to justify a more nuanced conclusion using HS Code data, particularly aggregated at the annual level.

Plywood trade has the smallest average Discrepancy Score, and the least clear trend in magnitude and direction of Discrepancy. Further analysis of specific Discrepancy Scores will provide some insight into the fluctuations around 0 in Plywood Discrepancies, in particular discussion of Plywood trade with China from 2012 - 2016 and Malaysia from 2007-2008 in discussion of the Partner View. Despite the ability to identify the partnerships responsible for these apparently irregular years, no clear conclusion is supported about the likely causes of such anomalous discrepancies and remain limited to interpreting and testing larger trends.

View 3 Summary Observations and Conclusions

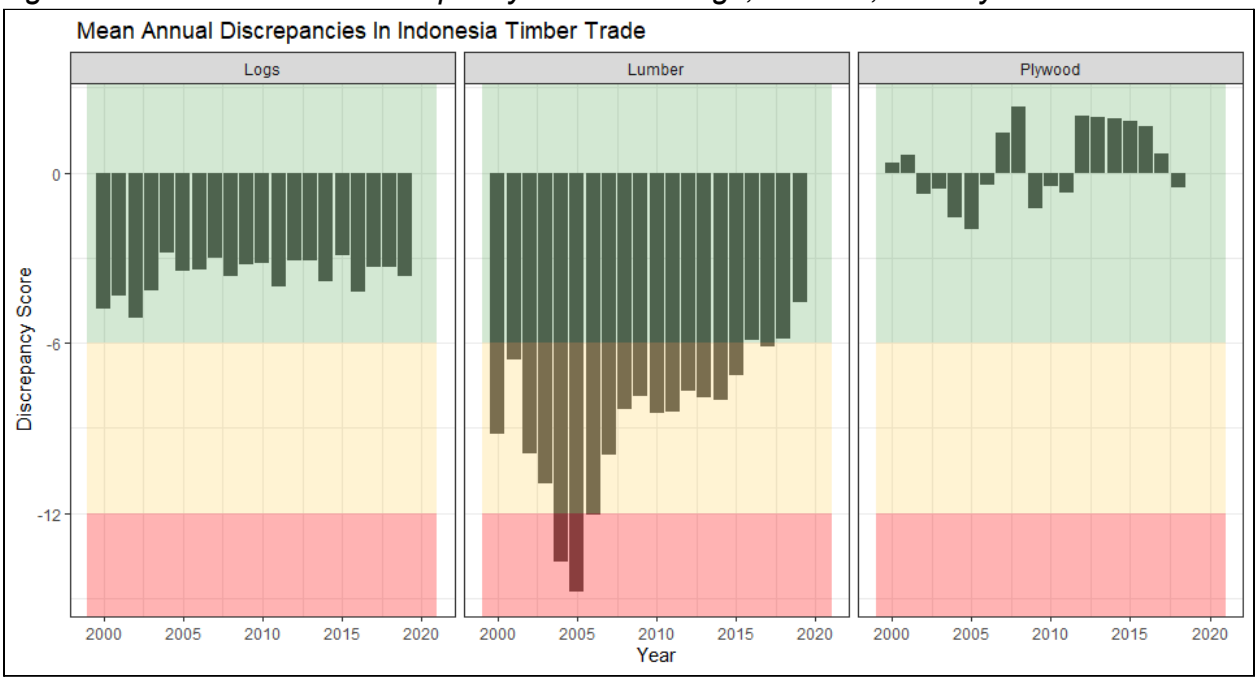
Indonesian Lumber Discrepancies are considerably more extreme than either Logs or Plywood, and are predominantly negative, indicating consistent underreporting by Indonesia compared to its top trade partners.

Log Discrepancy Scores also are consistently underreported by Indonesia compared to its top trade partners.

Lumber Discrepancy Scores trend less extreme over the study period.

Plywood Discrepancy Scores appear less extreme than either Logs or Lumber and are subject to more fluctuation between positive and negative Discrepancy Scores, or under- and over-reporting by Indonesia compared to its top trade partners.

Figure 19: Mean Annual Discrepancy Scores of Logs, Lumber, and Plywood



View 4: Partners

At this stage, markers of significant policy events are added to each panel to situate these trends within their policy context and inform the Policy Periods and related hypotheses tested in the Statistical Testing section. A visualization and brief interpretation follow.

Australia

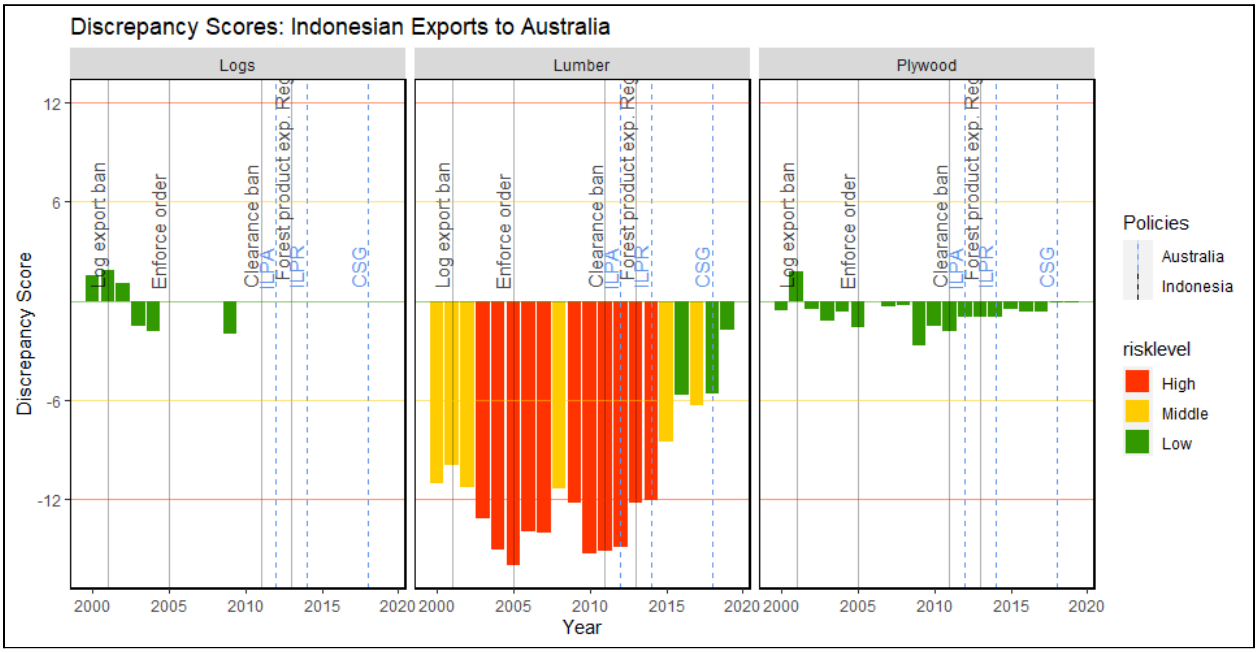
Log and Plywood discrepancies both appear to be minimal and therefore of lower risk of illegality detectable in trade data, and to exhibit only weak trends upon which to formulate hypotheses. Lumber Discrepancy Scores with Australia are extreme, with over 50% of years in the study showing a discrepancy in the most extreme third of the Discrepancy Score range and only three years in twenty falling in the least extreme range. The extremes peak twice - in 2005, which corresponds to the larger trend identified in the Aggregate View, and 2010, but appearing to nearly plateau from 2010 to 2012.

Indonesia's 2005 enforcement order followed a full log export ban in 2001, a timber export ban in 2004, and several years of increased seizures. This series of events appears to correlate with a sharp decline in Discrepancy Scores from 2005 - 2008. However, scores rebound to their extremes from 2010 - 2012. In 2012, Australia adopted the Illegal Logging Prohibition Act (ILPA), and in 2014 amended the act with the Illegal Logging Prohibition Regulation, then Indonesia and Australia developed a Country-Specific Guideline (CSG) in 2016 and co-signed the CSG in 2018, both under the framework of the ILPA. Scores drop between 2012 - 2014 but remain in the most extreme third, then continue to drop sharply through the end of the study. In the last 5

years studied through 2019, Australia's Lumber Discrepancy Scores are in the least extreme third for three years, and in the moderate range for two. This pattern is also visible with several other Partners and referred to hereafter as a "W-shaped" trend, indicating the two periods of relatively extreme and negative Lumber Discrepancy Scores.

Despite that Lumber appears to be of high risk of illegality over the entire study period, the declining trend since 2012 appears to be a considerable and prolonged reduction in high-risk Discrepancy Scores. This declining trend appears to be associated with both Indonesian and Australian policies, with declines in risk steeper and longer lasting under bilateral policy adoption. 2014 was selected as the most natural cutoff point to evaluate the difference before and after the ILP Regulation. The two-year window between ILPA and ILPR is too narrow to expect meaningful test results and consider the Regulation as the point of implementation of the Act. It would be quite valuable to conduct a similar analysis around the CSG adoption, but given its 2018 adoption date, there is insufficient data to construct an "after" comparison at this point in time.

Figure 20: Australia Discrepancy Scores



China

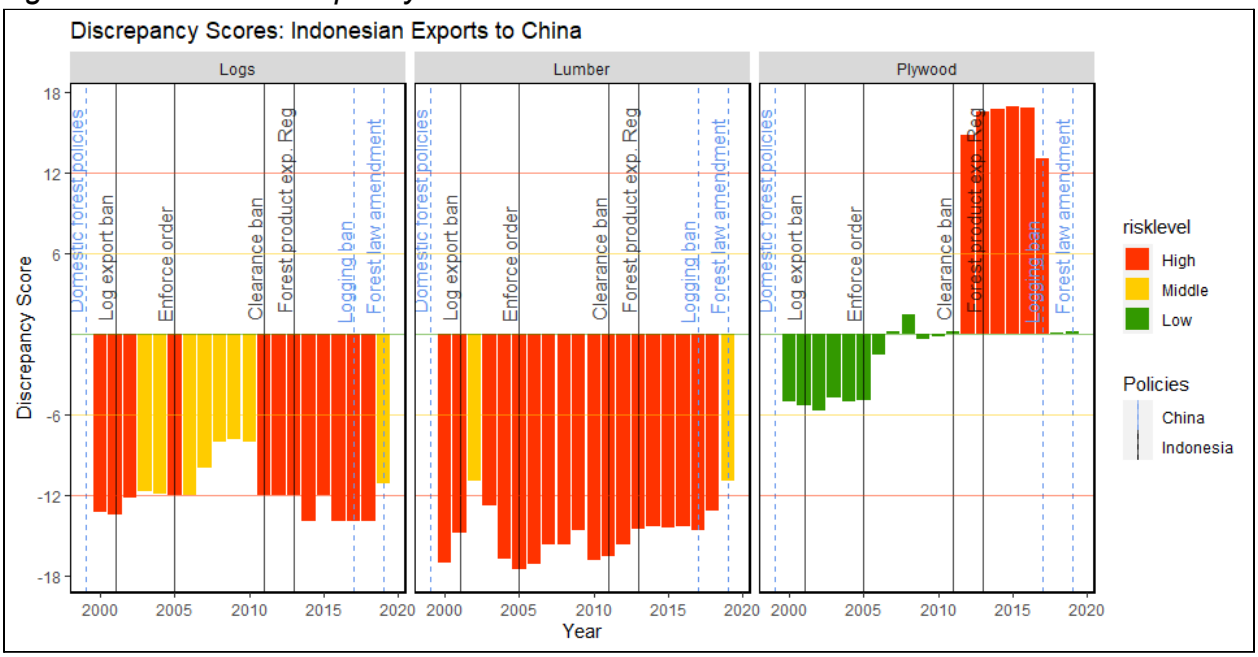
Timber trade with China exhibits the most consistent and extreme Discrepancy Scores among all of Indonesia's trade partners included in this study. Log Discrepancies Scores remain moderate (eight years) or high (12 years) throughout years studied; Log Discrepancy Scores are moderate in two years and high in 18; and Plywood scores are low risk for 14 years but high risk for a seemingly anomalous 6-year period from 2011-2016. Despite these extreme discrepancy scores, there is a several-year decline in extreme Discrepancies across all three Products following Indonesia's 2005 enforcement order before Scores become more extreme again in 2009 (Lumber), 2010 (Logs), and 2011 (Plywood). This pattern of decline for several years after 2005

followed by a return of extreme scores mirror the pattern seen in Australia's Lumber trade from 2005-2009.

After 2010, Log and Plywood Discrepancy Scores continue to rise for several years, while Lumber scores hit a lower (but still high risk) plateau. Contrary to several. Scores for all three products drop at the end of the study, with Logs and Lumber in the moderate range for 2019 and Plywood in the low-risk range in 2018-2019. However, these 1-2 years declines in the final years studied resist confident analysis as the longer-term trend is still taking shape. It is possible that China's National Forest Law Amendment has begun to increase scrutiny of imports, but this is unlikely given that implementing measures have yet to be adopted (Norman & Saunders 2017). China also adopted a National Forest Logging Ban in 2017, which would be expected to increase demand for timber imports to meet manufacturing and consumer demand no longer met by domestic production (Hui 2017). Without strong controls on imports yet in place, a growth in demand for timber imports should be regarded as an increased risk of illegality. Given these ambiguous policy signals around the end of the study, no testing was conducted, or conjecture would be reliable, before additional years of data reveal longer-term trends.

Among Indonesia's policies, the dynamics around the 2005 enforcement order continue to be intriguing, especially as scores drop after the order but also rebound within several years after. Equally interesting is the rise in Logs and Plywood Discrepancy Scores around the implementation of Indonesia's SVLK system via the Forest Product Export Regulation. While other nations demonstrate a drop in discrepancy scores around this time, the opposite appears true in the case of China. It is possible that China's increased protections for domestic forests and lack of timber import legality regulations combine to increase illegality in trade between China and Indonesia even while Discrepancy Scores and illegality fall in trade in more regulated markets. This can only be conjecture given data constraints. Test Series 6 provides greater insight into significant differences in Discrepancy Scores for partners with no import policy between Policy Periods.

Figure 21: China Discrepancy Scores



EU

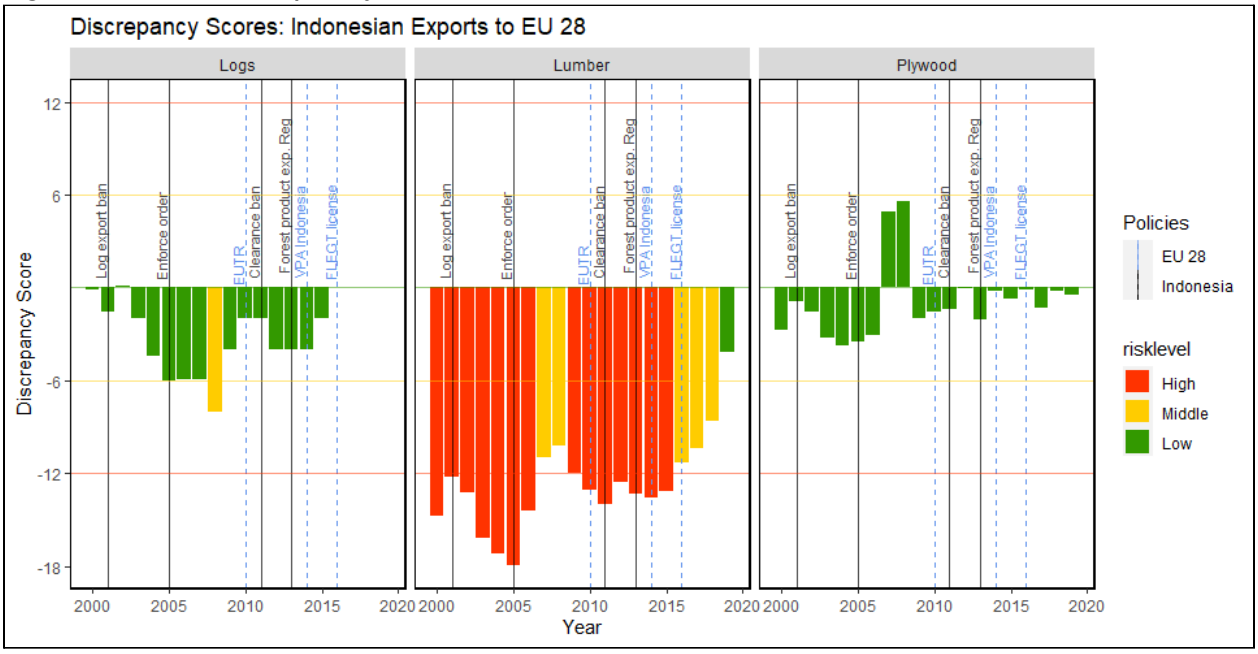
Discrepancy Scores with the EU mimic several trends also observed with other partners. Similar to Lumber Discrepancy Scores with the EU are much more extreme than either logs or plywood, with 14 of 20 years in the high range for lumber. Log trade in 2008 is the only instance in which either Logs or Plywood Discrepancy Scores reach the moderate risk level.

Lumber Discrepancy Scores with the EU exhibit a W-shaped trend also observed with Australia and the United States, and perhaps weakly visible in trade with Taiwan and China. Lumber Scores reached their most extreme in 2005; following Indonesia's enforcement order that year, Scores trend less extreme through 2008, increasingly extreme from 2008-2010, and approximately plateaued at high risk levels until beginning a trend toward less extreme after 2014 and through the study's end.

There may be a relationship between several key policy events and the decline in Lumber trade risk between 2014-2019. Indonesia's Forest Product Export Regulation in 2013 put its SVLK timber legality system into implementation. The Voluntary Partnership Agreement (VPA) under EU FLEGT was signed by the EU and Indonesia in September 2013 and included in these visualizations and later statistical testing as entering implementation in 2014. Indonesia's attainment of full FLEGT timber import licensure in 2016 may also have influenced the decline in Discrepancy Scores in recent years. These policy events are mutually influential. The EU's VPA process with Indonesia began in 2013 (EU FLEGT 2018) and included negotiations and collaboration to design Indonesia's SVLK timber legality systems (EU FLEGT 2018). The SVLK became central to negotiations between the partners leading up to Indonesia gaining full FLEGT licensure which grants import access to all timber licensed under SVLK (Wibowo &

Giessen 2018; UN 2014). Given the close association and tight timelines between these policy events, 2014 is judged as both a turning point from a plateau of high-risk trade to a trend or falling risk, as well as the year that meaningful bilateral trade agreements began to take shape.

Figure 22: EU Discrepancy Scores



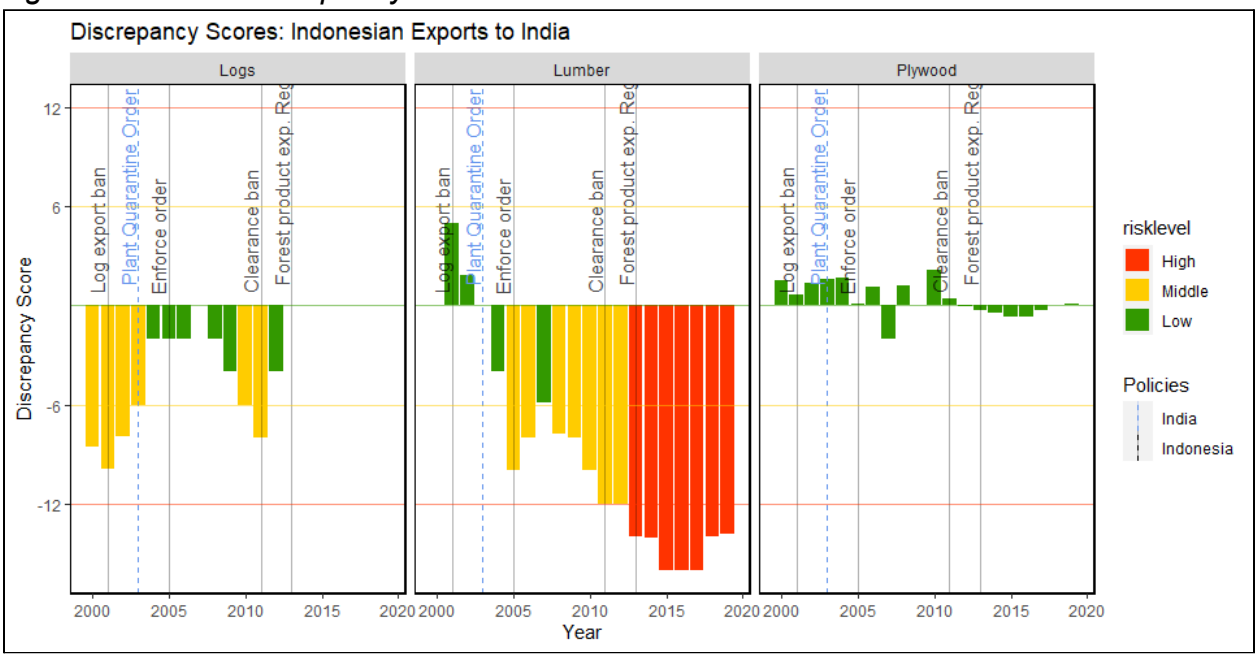
India

In the case of India, dissimilarities from trends with other Partners appear much more prominent than similarities. Beginning with similarities: Plywood Discrepancy Scores are relatively small and fluctuate between low negative and positive values, and therefore show little cause for concern from a trade analysis perspective. Lumber Discrepancy Scores with India are more extreme than Logs or Plywood, a quality shared in all trade partnerships studied. Lumber, and possibly Logs, also exhibit a trend of normalizing Discrepancy Scores after Indonesia's 2005 enforcement order, followed by an increase in extreme scores in both of these categories after 2008. It is possible that India's Plant Quarantine Order of its 2017 5-year update to the Export Import policy, but neither of these contains specific wood product restrictions (Directorate of Plant Protection 2015; Sood 2019; Norman & Canby 2020) and are unlikely to drive a reduction or stave off an increase in extreme discrepancies.

Focusing on Lumber Discrepancies, India's trend departs from trends with all other trade partners from 2010 to 2019, with the United States the only clear exception and China ambiguous given a short-term decline in 2018-19. During this period, Lumber Discrepancies continue to rise steadily and reach our range for high risk of illegality each year from 2013 to 2019. These seven years of extreme Scores may be read either as a seven-year plateau or a peak from 2015-2017 followed by a slight drop in 2018-19. Only additional years of data will enable a confident assessment of the distinction

between these, but the overall trend is clear: while nearly every other Partnership saw a decline in Lumber Discrepancy Scores, trade with India exhibits a steep increase in extreme scores. Trends with India are included in Test Series 3 and 6, providing evidence for concern that India's loosely regulated and quickly growing timber imports are susceptible to growing illegality as its other nations adopt more strict import and export policies.

Figure 23: India Discrepancy Scores



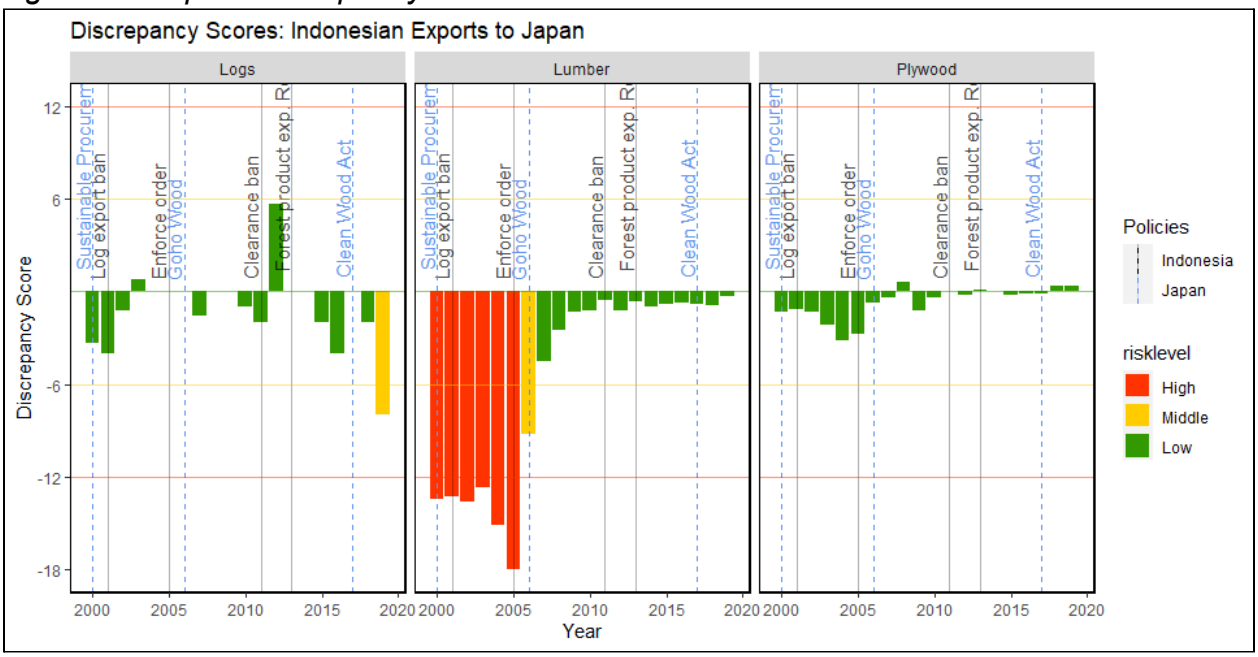
Japan

Trade with Japan exhibits perhaps the most precipitous decline in extreme Lumber Discrepancy Scores, which reached the top 33% high risk category each year from 2000 to 2005. A steep decline begins in 2006 reaching the moderate risk level, followed by low-risk Scores from 2007 to 2019 and a trend that appears to fall closer to 0 over time. Indonesia's 2005 Enforcement Order and Japan's "Goho Wood" expansion of its public procurement policy in 2006 coincide with this decline. The combination of Test Series 1 which focuses on Indonesia's Policy Periods, and Test Series 5 focusing on Partner policies and Lumber will enable us to comment on the significance of differences in trends around these policy events.

Logs exhibit no clear trend over the study period, with the possible exception of increased Discrepancy toward the end of the study, but additional years of data would be necessary in order to meaningfully interpret or test this observation. However, there may be slight cause for concern given Indonesia's log export ban and the small but not declining divergence from 0 Discrepancy Scores in logs. Plywood Discrepancies, though at no point during the study exceeding the low-risk level, appear to show a slight trend of deviating less far from 0 Discrepancy Scores. The "Data Overview" Section above shows that Japan is Indonesia's largest timber trade partner (33% of export

value), and plywood is the most valuable timber export product (84.5% of export value). Given the outsize importance of plywood and Japan in Indonesia's timber exports, this visualization indicates that little risk of timber illegality is detectable from trade data for this partnership. Japan's 2006 Goho Wood procurement expansion and 2017 implementation of the Clean Wood Act analysis are included in Test Series 5.

Figure 24: Japan Discrepancy Scores

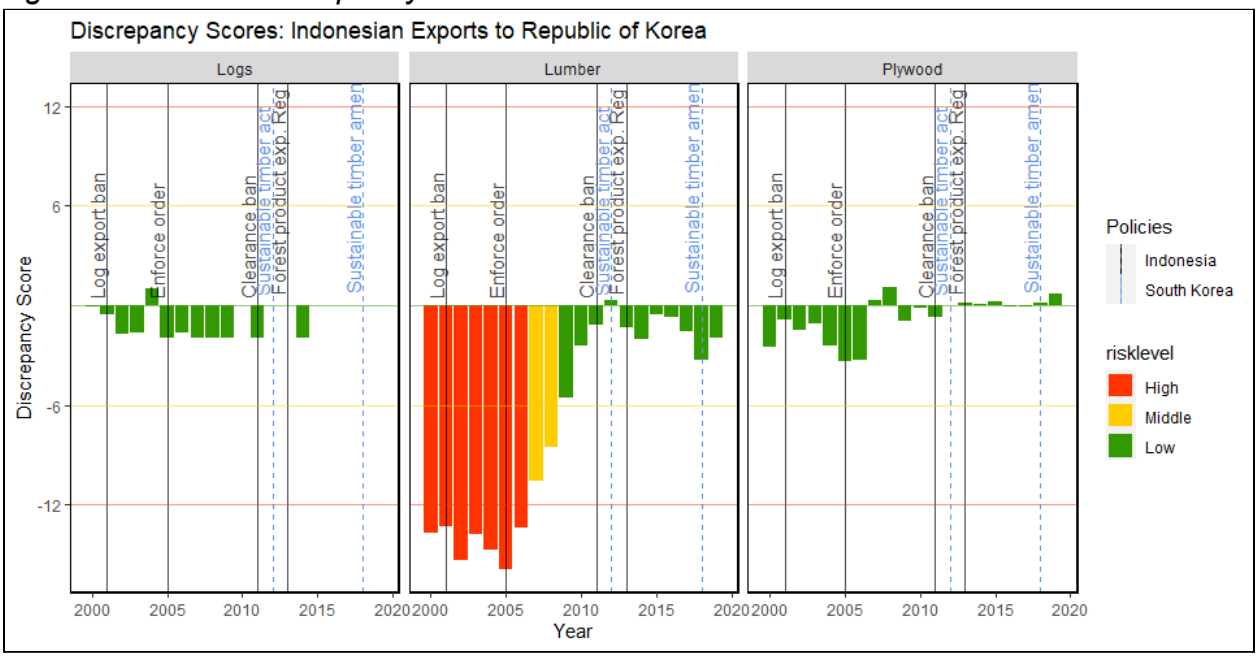


Korea

Discrepancy Score trends appear remarkably similar between Korea and Japan. For Korea, Logs and Plywood also do not exceed the low-risk Discrepancy Scores threshold; and each of these categories exhibits a slight decrease in extremity of Discrepancy Scores over the period of the study.

Plywood Discrepancy Scores were in the high-risk range for the first seven years of the study (compared to Japan's first six), show a steady decline in extreme scores from 2005 to 2011, and remain negative but in the low-risk range through the study end in 2019. The declining trend following a 2005 peak is consistent across all partners, appears related to Indonesia's 2005 Enforcement Order, but not associated with any specific Korean timber import policy during this period. Similar to Japan, policy events and adoptions after this steep decline are not visibly associated with clear Discrepancy Score trends. Despite this, Test Series 1 and 3 look for significant differences in Discrepancy Scores around Indonesia's policy events, and Test Series 5 includes Korea's policy events.

Figure 25: Korea Discrepancy Scores



Malaysia

Discrepancy Scores with Malaysia in all three Products show a decrease in extremity over the study period. Logs Scores are in the high-risk range for the first three years of the study, and Lumber are high risk in seven of the first eight years. Plywood Scores follow a more ambiguous trend but do appear to fluctuate less var from zero from beginning to end of the years studied. Log Scores fall into the low range for the final 5 years of the study; Lumber and Plywood for the final 11 years. These high-level trends, enable the conclusion that Indonesia's timber exports with Malaysia shifted from moderate or high to low risk of illegality from 2000 to 2019.

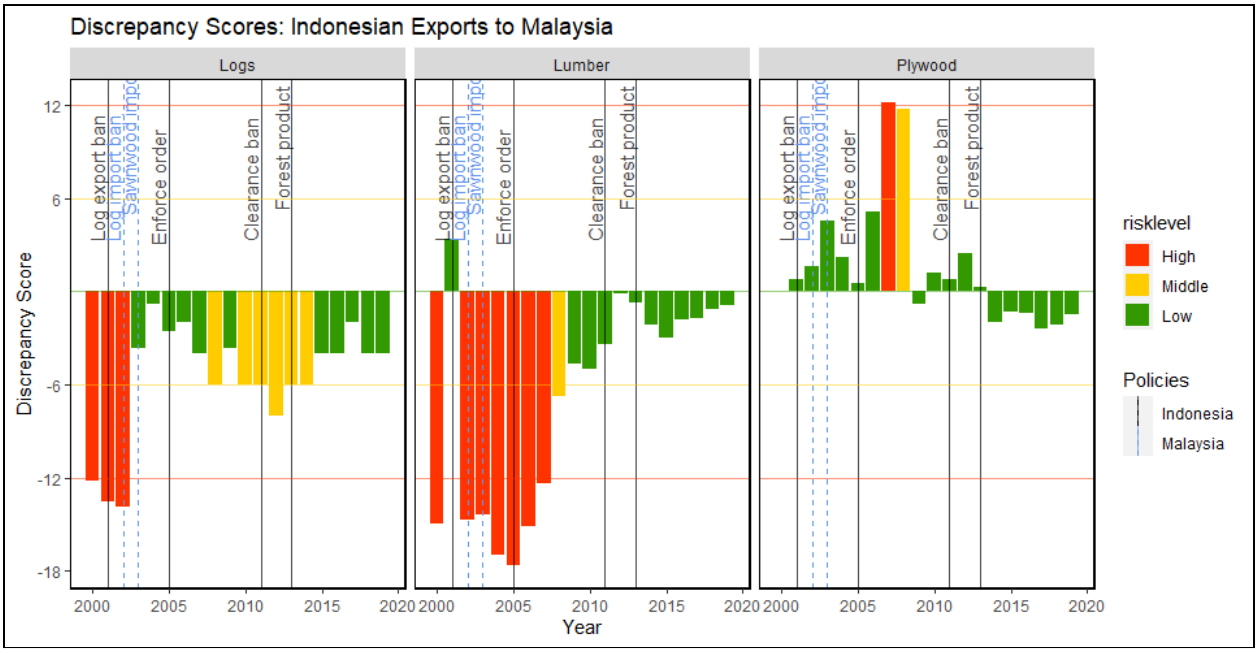
Log Discrepancy scores decreased in extremity greatly after 2001 following Indonesia's In Lumber export ban in 2001 and Malaysia's complementary Log Import ban in 2002. However, given the lack of annual data prior to these policy adoptions, statistical testing around these dates is unreliable and therefore no specific tests are constructed around them. Though the overall trend in Log trade with Malaysia is toward less extreme Scores, several years of moderate risk scores peak in 20212 before decreasing and remaining in the low-risk range between 2015-2019.

In Lumber, there is a repetition of the decline in extreme Scores after 2005 and Indonesia's Enforcement Order. Rather than exhibiting the rebound in Discrepancy Scores seen in some nations, Malaysia's trend mirrors that of Japan and Korea in continuing to decrease to low-risk and remain within the range through the end of the study period.

Plywood Scores with Malaysia are more difficult to interpret. Scores are consistently positive through 2008, and negative from 2009-2019. All years show low-risk

Discrepancy Scores, with the exception of 2007-2008 which are respectively high and moderate risk, and apparently anomalous both within this partnership and the entire dataset (for an easy visual comparison to other Partners, see the visualization titled "Plywood Discrepancy Scores by Partner Country" in Appendix 3). Literature review and the current analysis have not revealed an explanation for this observation, and in general data in aggregated Product categories (see Appendix 1) are unlikely to provide insight at this level of granularity.

Figure 26: Malaysia Discrepancy Scores



Singapore

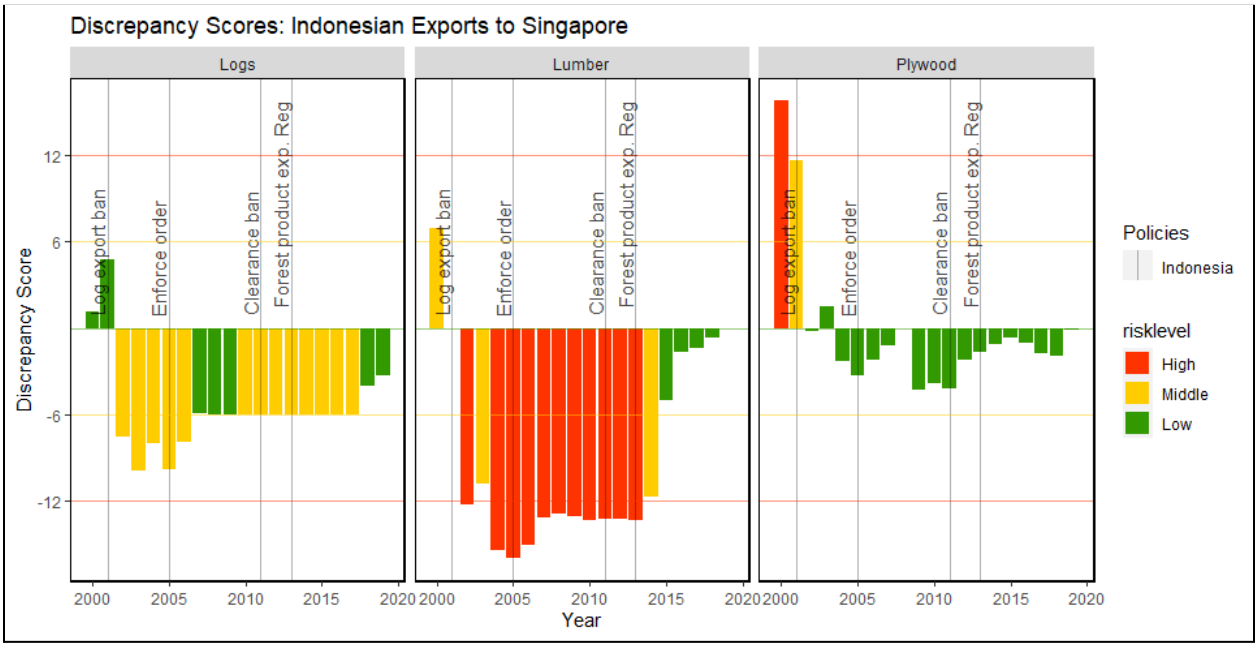
Like India and China, Singapore has no specific timber import policy beyond its adoption of CITES commitments, and at least in the early 2000s had a reputation as a central shipment hub for enabling and obscuring illegal timber trade. During this study, Indonesian timber trade with Singapore exhibits a large decrease in extreme Discrepancy Scores overall, with the most notable shift in Lumber trade.

Unique to this trade Partnership, Discrepancies were positive in each Product category for 2000-2001 when Indonesia re-instituted its full log export ban, after which all Discrepancies became negative for the remainder of the study. Given that this study begins in 2000, it is not possible to examine this trend in greater detail but is worthy of mention and future consideration.

Singapore Discrepancy Score appears to drop after a 2005 peak concurrent with Indonesia's 2005 Enforcement Order, though the decline in extreme Scores after this Order appears small in all three Products. With the exception of years 2000-2001, in the high and moderate risk range respectively, Plywood Scores remain in the low-risk

range. These data and policy literature review are insufficient to inform a solid conjecture or test data at the far ends of the time series with any confidence.
Log scores remain quite consistent and moderate or low from 2007 - 2017 before dropping to low in 2018-19. Lumber scores follow a similar trend: consistently high from 2007 - 2013, followed by declining extremity and low scores from 2015-2019. While the decline in Lumber scores coincides with Indonesia's 2013 Forest Product Export Regulation in 2013, the same is not true in Logs, which remain constant for several years after.

Figure 27: Singapore Discrepancy Scores



Taiwan

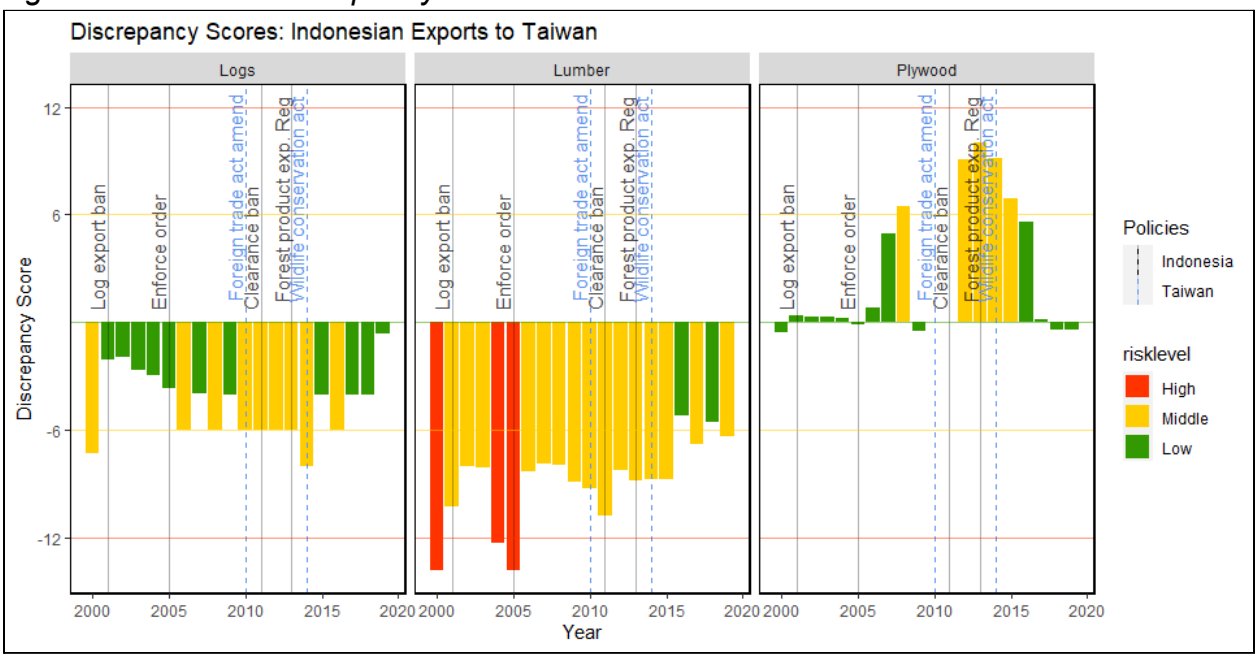
Taiwan's policy context is somewhat unique: given disputes over independence from China, Taiwan is not an official signatory to CITES, but instead voluntarily adopted national laws to be in compliance with CITES standards through the Foreign Trade Act Amendment (TMEA 1993) and updated through the Wildlife Conservation Act (TCA 2013). which may indicate a more active implementation of the CITES standards. Trends and levels of Discrepancy Scores in Indonesian trade with Taiwan are something of a middle ground of the nations studied.

The trends in each Product are somewhat ambiguous across the study period, and while each Product exhibits a pattern of moderate risk Discrepancies. Scores are consistently negative in Logs and Lumber, and mostly positive in Plywood, and exceed the high-risk threshold only in Lumber, only for three years, and all three before 2006. The trend of decreased extremity in Scores after 2005 is visible only in Lumber, after which Scores rebound slightly but remain in the moderate range before fluctuating between moderate and low risk from 2016-19; the overall trend in Lumber Scores is toward smaller Discrepancies over the study. The pattern after 2005 in Logs and

Plywood actually moved in the opposite direction, becoming more extreme for three years in Plywood and as many as nine in Logs (depending on how one reads the fluctuation during this period. Plywood appears to show larger Discrepancies later in the study, and Logs do not exhibit a clear rise or fall in Discrepancy extremity over the study.

The relative spike in Plywood discrepancies from 2012 - 2016 roughly correspond with high Discrepancies rates between Indonesia and China during the same period, as possible indication that Taiwan's timber markets are influenced by Chinese policy and / or trade. Taiwan has no more specific Import policy than the Foreign Trade Act Amendment (USDA 2020), and there is no observable clear shift in Discrepancy trends in any Product. Nevertheless, FTA Amendment is included in Test Series 5 alongside other nations with more explicit import policies.

Figure 28: Taiwan Discrepancy Scores



Thailand

Trends in Discrepancy Scores with Thailand most nearly mimic those with Japan and Korea, though in a less extreme form. At the high level, Plywood appears to remain close to zero Discrepancy for the entire study and appears of little concern for timber illegality risk detectable through trade discrepancies. Logs and Lumber each exhibit moderate scores in multiple years in the earlier years of the study, shifting to very low discrepancies in Lumber from 2008 to 2019, and 0 Discrepancy Score from 2004 - 2019.

In Logs, the flatlining of Discrepancy Scores at zero in 2004 after its peak in 2000 appears and may well be related to Indonesia's 2001 Log Export Ban, but this cannot be statistically validated given that the study begins in 2000. Lumber Discrepancy

Scores peak in 2004, just before Indonesia's 2005 Enforcement Order, after which Scores continue to fall until reaching a consistently near-zero Discrepancy Score in 2011 through the study's end. Significant dates related to Thailand's VPA with EU in this visualization are included, but do not consider these as full import policies at this stage and therefore include Thailand in Test Series 6 which focuses on Indonesia's Partners without Timber import policies.

Figure 29: Thailand Discrepancy Scores

United States

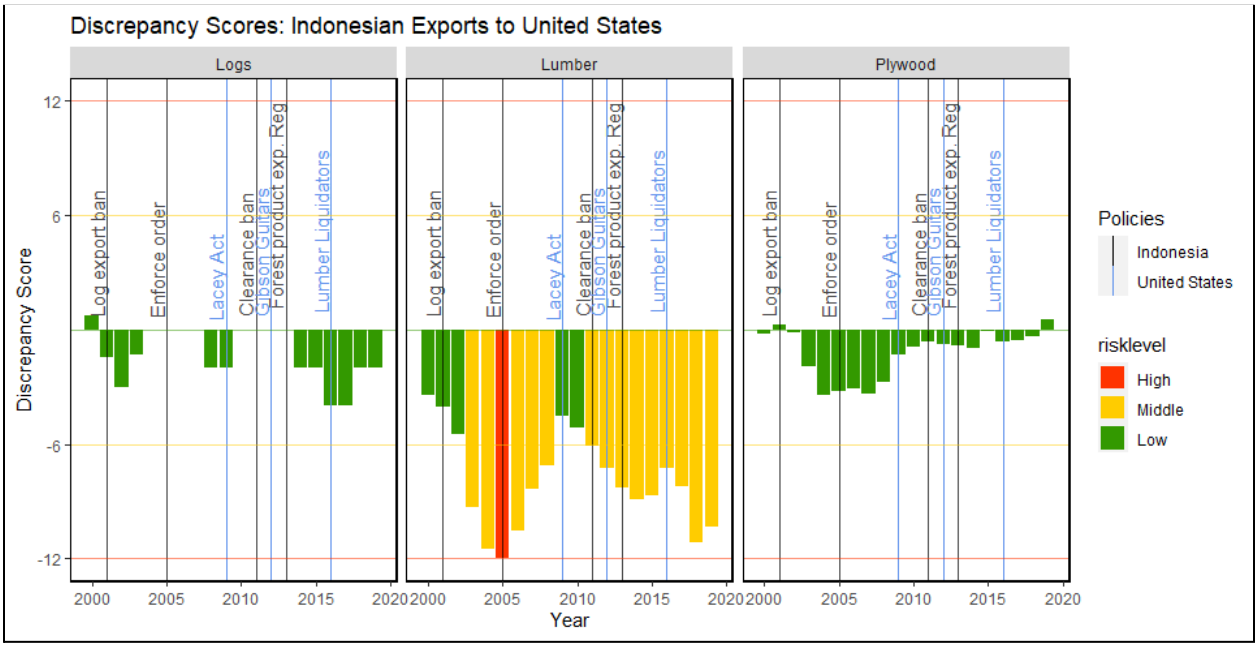
The USA is one of only two nations not showing an overall decrease in Lumber Discrepancy Score extremes over the course of the study (the other being India). Through 2014 the USA's Lumber Scores appear to follow the "W trend" discussed with Australia and the EU: 2000 to 2005 show Lumber Scores increasing and peaking; decreasing from 2006 to 2009; and rebounding through 2014. However, after 2014 the USA's Lumber Scores only became less extreme for a year before increasing again through the end of the study, while the EU and Australia saw consistent reduction in extreme scores from 2014 to 2019. Though these data do not permit testing for significance at this level of granularity, it bears noting that both the EU and Australia were engaged specifically with Indonesia in designing illegality reduction measures during this period. Shelley (2012) noted the lack of a framework or requirement for international cooperation as a shortcoming of the Lacey Amendment.

The US Lacey Act Amendment in 2008 and updated to include Wood Product HS codes in 2009 appears not to be related with a shift toward decreased Discrepancies in any of the products studied. On the contrary, Lumber Discrepancy Scores between Indonesia and the USA rise steadily after 2009, while Logs and Plywood exhibit no notable shifts after Lacey implementation. Further, two most notable enforcement cases of Lacey Act

are include in the visualization below: Gibson Guitars (Clarke 2012; EU FLEGT 2012b) and Lumber Liquidators (USDOJ 2016) that resulted in penalties in 2012 and 2016, respectively. These enforcement events also appear to have no clear association with Log or Plywood Discrepancies Scores shifting; Gibson and Lumber Liquidators do both occur during times of increasing risk in Lumber Discrepancy Scores, but there is no reason to believe that these explain the trend in any way, given that the theory of enforcement assumes an ensuing reduction in illegality, and neither enforcement case was in any way specific to Indonesian imports.

The United States is included in all nation-specific rounds of testing focused on Indonesian Policy Periods (Test Series 1, 3, and 4). Lacey Act Amendment implementation in 2009 is selected for Test Series 5 which focuses on Partner with import policies.

Figure 30: United States Discrepancy Scores



View 4 Summary Observations and Conclusions

Indonesia's 2005 Enforcement Order and 2013 Forest Product Export Regulation are the most pertinent policy events around which to construct Policy Periods in the following Statistical Testing section.

There is a decreasing extremity in Lumber Discrepancy Scores among several partners from 2005 to 2008. After this period, two trends are each repeated among multiple (but not all) partners: One, a several-year rebound in extreme Scores (Strongly in Australia, China, EU, and weakly in India, Taiwan, and United States). Two, a continued decline in Scores through the study period (Japan, Malaysia, Korea, and Thailand). This informs the decision to further divide Policy Periods for Statistical Testing section after 2008.

There is a declining trend of extreme Discrepancy Scores among multiple Partners (Australia, EU, Singapore, Taiwan, and possibly China) as well as new import policy adoption (Australia, EU, Korea) in and around 2013 implementation of Indonesia's Forest Product Export Regulation. This informs the decision to further divide Policy Periods used in the Statistical Testing series after 2013.

The resulting four Policy Periods used for statistical testing are: 2000 - 2005, 2006-2008, 2009 - 2013, and 2014 - 2019. These are discussed in greater detail in the Methods section.

A majority of trade Partnerships exhibit a trend of decreased extremity in Lumber Discrepancy Scores over the study period. India and the United States are the only clear exceptions, with China ambiguous given a short-term decline in 2018-19.

Among nations with no timber import policy (China, India, Singapore and Thailand), China and India are the only two Partners for which Discrepancy Scores appear to contradict the general trend of decreasing extremity of Discrepancy Scores. This applied to Log trade with China, Lumber trade with India and possibly China, and Plywood trade with China.

Discrepancies Statistical Testing

The previous section's discussion of visualizations informs the intuition and hypotheses statistically analyzed in this section. Given the many-dimensional space of this dataset, which includes eleven Partners, four Time Periods, three Product Categories, and multiple Partner Policies, a series of statistical tests enable a more precise identification of which Partners, Products, and Policies exhibit statistically significant changes over the study period.

First is an ANOVA test comparing mean Discrepancy Scores for each Partner in all four Time Periods, with Product categories aggregated into one. These are supplemented by Tukey tests for Honestly Significant Differences between Policy Time Periods. Null hypotheses for these tests: There is no difference in mean Discrepancy Scores with a given Partner across the four Periods.

Second is an ANOVA test comparing mean Discrepancy Scores in each Product Category in all four Time Periods, again following with Tukey HSD tests to identify significant differences between Time Periods. Null hypotheses for these tests: There is no difference in mean Discrepancy Scores from a given Product Category in the four Policy Periods

Third is an ANOVA test comparing Lumber Discrepancy Scores in all flour Periods for each Partner. This is followed by a TUKEY HSD test on India alone to provide greater insight into this Partnership with an anomalous trade. Null hypotheses for these tests: There is no difference in Lumber Discrepancy Scores for a Given Partner in the four Policy Periods.

Fourth are two-sided t-tests with unequal variance to test the “before-and-after” periods on Lumber Discrepancy Scores for each of two Indonesia policies. Null hypotheses for these tests are: There is no difference in mean Lumber Discrepancy Scores before and after a given Indonesian policy takes effect.

Fifth are two-sided t-tests with unequal variance to test the “before-and-after” periods on Lumber Discrepancy Scores for each specific national trade policy. Null hypotheses for these tests are: There is no difference in mean Lumber Discrepancy Scores between Indonesia and a given Partner before and after a given policy takes effect.

Sixth are two-sided t-tests with unequal variance to test for difference in Lumber Discrepancy Scores between Indonesia and trade partners lacking an import policy, before and after implementation of each of two Indonesian policy events. Null hypotheses for these tests are: There is no difference in mean Lumber Discrepancy Scores between Indonesia and a given Partner before and after a given policy takes effect.

Tests Series 1: ANOVA Tests on Effect of Time Period on Mean Discrepancy Scores by Partner

The first series consist of One-Way ANOVA tests at the aggregated Product level, dividing the data into the four policy periods discussed in the Methods section. The Null Hypothesis for each of these tests is: There is no difference in mean Discrepancy Scores with a given Partner across the four Periods. The Alternate Hypothesis is: Mean Discrepancy Scores with Partners differ significantly between the four Periods. Results are shown in Table 1.

Only 3 nations showed a statistically significant change in Discrepancy Scores over all product groups and time periods at the 95% confidence level. Those were Japan ($p = 0.00062$), Korea ($p = 0.00125$) , and Thailand ($p = 0.00011$), each of which exhibited a declining trend in Discrepancy Scores over the study period. Japan and Korea have perhaps more meaningful results than Thailand. Japan ranks first, Korea fourth, and Thailand fifteenth among Indonesia’s largest timber trade partners (see Figure 2 in Section 3). In each of these cases, the null hypothesis that there is no difference in the mean discrepancy scores across the 4 times periods is rejected. Singapore ($p = 0.08189$) tested as significant at the 90% level, but no comparison between specific time periods using a Tukey test was significant, and therefore this result is not considered strong evidence.

Both Japan and Korea exhibit high risk discrepancies early in the study, put timber import policies into place during the study period, and show a statistically significant decrease in discrepancy risk. Thailand exhibited only moderate risk levels of discrepancies, did not adopt specific timber import policies, and has nonetheless seen a significant decline in discrepancy scores over the study period. Given this lack, it appears that Indonesia’s domestic policies and general concern over illegal trade in the global timber market contribute to the decline in discrepancy scores with Thailand.

Tukey tests enabled comparison between specific time periods contained in the ANOVA tests and shown in Table 2. Japan has significant p values between periods 1:2 (0.0937762), 1:3 (0.0009365), and 1:4 (0.0037502); Korea between periods 1:3 (0.0107458) and 1:4 (0.0026770); and Thailand between Periods 1:2 (0.0534566), 1:3 (0.0006989), and 1:4 (0.0003268). These p-values indicate that President Yudhoyano's enforcement order in 2005 is associated with a steady decline in Discrepancy Scores over the study period, indicating that indeed less illegal timber product is flowing from Indonesia to at least these significant trade partners. This confirms the qualitative interpretation of Figures 24 (Japan), 25 (Korea) and 29 (Thailand), which show clear declines after 2005 (when Period 1 ends) in Lumber Discrepancy Scores in all three of Japan, Korea, and Thailand, as well as a similar trend in Discrepancy Scores for Logs trade with Thailand.

Test Series 1 Summary Observations and Conclusions

There are significant differences in Mean Discrepancy Scores for aggregated timber Products exported from Indonesia to Japan, Korea, and Thailand. This corroborates previous interpretation of View 2, in which there is a slight decrease in Discrepancy Scores at the Aggregated Product level.

There is a decrease in risky Discrepancy Scores for aggregated Products when comparing Policy Period 1 (2000-05) to both Period 3 (2009-13) and Period 4 (2014-19) for Indonesian timber Trade with all three or Japan, Korea and Thailand.

Table 1: Test Series 1 ANOVA Results

Test Series 1: ANOVA on Effect of Time Period on Mean Discrepancy Scores by Partner					
Partner	**Df**	**Sum Sq**	**Mean Sq**	**F value**	**p value**
Australia	3	66.23	22.08	0.6683	0.5751
China	3	301.60	100.52	1.1113	0.3522
EU 28	3	75.23	25.08	0.7305	0.5381
India	3	189.36	63.12	2.0388	0.1198
Japan	3	315.34	105.11	6.6749	0.0006
Korea	3	311.54	103.85	6.0249	0.0012
Malaysia	3	184.58	61.53	1.658	0.1865
Singapore	3	260.05	86.68	2.3527	0.0819
Taiwan	3	45.23	15.08	0.4806	0.6971
Thailand	3	202.44	67.48	8.4549	0.0001
United States	3	24.17	8.06	0.5968	0.6197

Table 2: Test Series 1 Tukey HSD Results

Test Series 1: Tukey HSD Tests of Time Periods for Partners with Significant Results from ANOVA Series 1					
Partner	**Periods Compared**	**Difference**	**Lower**	**Upper**	**Adjusted p value**
Japan	2-1	3.85	-0.44	8.14	0.0938
	3-1	5.60	1.93	9.27	0.0009
	4-1	4.75	1.25	8.26	0.0038
	3-2	1.75	-2.68	6.18	0.7230
	4-2	0.91	-3.38	5.19	0.9438
	4-3	-0.85	-4.52	2.83	0.9286
Korea	2-1	1.31	-3.18	5.80	0.8670
	3-1	4.69	0.85	8.54	0.0107
	4-1	5.13	1.46	8.79	0.0027
	3-2	3.39	-1.25	8.02	0.2258
	4-2	3.82	-0.67	8.31	0.1219
	4-3	0.43	-3.41	4.28	0.9907
Thailand	2-1	3.03	-0.03	6.09	0.0535
	3-1	4.10	1.48	6.72	0.0007
	4-1	4.41	1.74	7.08	0.0003
	3-2	1.07	-2.09	4.23	0.8064
	4-2	1.38	-1.82	4.59	0.6637
	4-3	0.31	-2.47	3.10	0.9906

Test Series 2: ANOVA on Discrepancy Scores for Product Categories across Time Periods

ANOVA tests were used to compare mean Discrepancy Scores in each Product Category in all four Time Periods. Each of the following is an unpaired, two-sample t-test with unequal variance evaluated at the 95% confidence level. In each case, the Null Hypothesis is: There is no difference in Mean Discrepancy Score in each product category and across all Periods. The Alternate Hypothesis is: Mean Discrepancy Scores differ in each product category between Periods.

Table 2 shows results of the ANOVA test of mean Discrepancy Scores in all four Periods with all Products aggregated. This tests the Null Hypothesis that there is no difference in Mean Discrepancy Scores between Periods and returns a p-value of 0.002103. The null hypothesis is rejected at the 99% confidence level enabling the observation that

Discrepancy scores differ between time periods. Figure 31 and Table 4 show results of a Tukey HSD test that identifies a significant difference between Discrepancy Scores from Period 1:4 at the 95% confidence level (p = 0.0009901); and a difference between Periods 1:3 significant at the 90% Confidence level (p = 0.0748170). Combining with intuition from View 2, this test shows that Indonesia's mean trade Discrepancy Scores fall from the beginning to the end of this study period. More specific insight into this general trend is gained by disaggregating Product Categories,

To this end, one ANOVA test of mean Discrepancy Scores is run in each Product across all for Periods. Results of these tests are also found in Table 3. The Null Hypothesis for each of these tests is: There is no difference in mean Discrepancy Scores between Periods for a given Product. For Lumber, the ANOVA test returns a p-value of 1.703e-05, allowing us to reject the null hypothesis at the 99% Confidence Level and say that there is a difference in Lumber Discrepancy Scores across the Periods studied. These tests combine with interpretation of View 3, Figure 19 to inform the conclude that Lumber Discrepancy Scores decreased in risk from beginning to end of the study.

Table 4 and Figure 32 shows results from a Tukey HSD test for significant differences in Lumber Discrepancies in the four Policy Periods. There is significant difference when comparing period 1:3 (p = 0.0294789), 1:4 (p = 0.0000161), and 2:4 (p = 0.0062705), enabling us to conclude a significant difference in Lumber Discrepancy Scores between the beginning and end of this study. Logs (p = 0.7141) do not exhibit a significant difference between periods, and plywood (p = 0.0694) exhibits a significant difference only at the 90% confidence interval. The Null Hypothesis that there is no difference in mean Discrepancy Scores for Logs and Plywood between Policy Periods cannot be rejected. This Product-specific analysis in View 3 shows a trend toward decreasing discrepancies is clear in Lumber trade, but more ambiguous in either Logs or Plywood.

These initial two series of ANOVA tests begin to tell a clearer story about Indonesia's Trade Discrepancies. Views 2 and 3 inform the intuition that Indonesian Lumber is of much greater risk for illegality than either Logs or Plywood, and this is supported by tests finding Lumber to be significantly different from the beginning to the end of the study, while Discrepancy Scores for Plywood are only weakly significant, and Logs are no significant between Policy Periods. This informs the conclusion that Lumber is the Product of chief concern in Indonesia's illegal timber trade.

Test Series 2 Summary Observations and Conclusions

Lumber exports from Indonesia exhibit the highest risk of illegality of Logs, Lumber and Plywood and Lumber is therefore the product of chief concern in Indonesia's efforts to identify and reduce trade in illegal timber.

Lumber Discrepancy Scores decreased in risk from beginning to end of the study.

Table 3: Test Series 2 ANOVA Results

Test Series 2: ANOVA on Effect of Time Period on Mean Discrepancy Scores by Product					
Product	**Df**	**Sum Sq**	**Mean Sq**	**F value**	**p value**
All products	3	513.9	171.31	4.9482	0.0021
Logs	3	23.1	76867	0.4549	0.7141
Lumber	3	779.7	259.915	8.7376	1.70E-05
Plywood	3	104.22	34.74	2.3934	0.0694

Table 4: Test Series 2 Tukey HSD Results

Test Series 2: Tukey HSD Tests of Time Periods for Products with Significant Results from ANOVA Series 1					
Product	**Periods Compared**	**Difference**	**Lower**	**Upper**	**Adjusted p-value**
All Products	2-1	1.0794	-0.7861	2.9449	0.4439
	3-1	1.4993	-0.0982	3.0968	0.0748
	4-1	2.2606	0.7194	3.8018	0.0010
	3-2	0.4199	-1.5068	2.3465	0.9434
	4-2	1.1811	-0.6991	3.0614	0.3691
	4-3	0.7613	-0.8534	2.3760	0.6179
Lumber	2-1	0.7429	-2.2678	3.7535	0.9193
	3-1	2.7738	0.1996	5.3520	0.0295
	4-1	4.5749	2.1167	7.0331	0.0000
	3-2	2.0309	-1.0785	5.1403	0.3309
	4-2	3.8320	0.8213	6.8427	0.0063
	4-3	1.8011	-0.7771	4.3793	0.2720

Figure 31: Tukey HSD Aggregated Product Policy Period Comparison

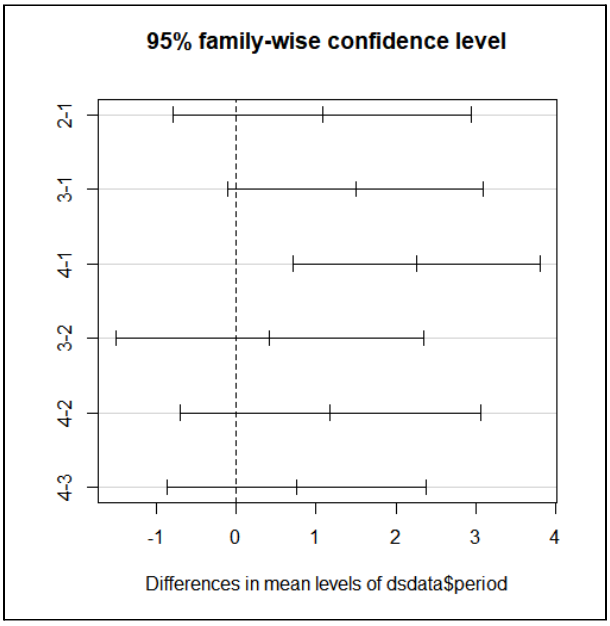
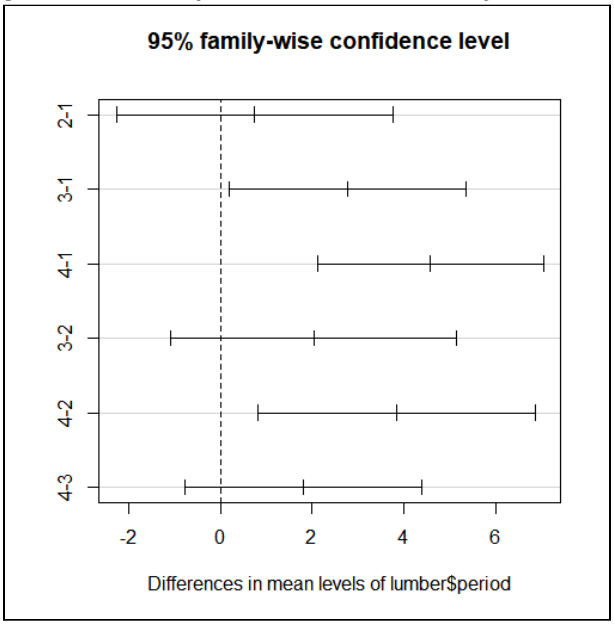


Figure 32: Tukey HSD Lumber Policy Periods Comparison



Test Series 3: ANOVA test on Lumber Discrepancy Scores by Partner

Analysis is then narrowed to gain better insight into Lumber Discrepancy Scores with each specific Partner. The Null Hypothesis is: There is no difference in mean Lumber Discrepancy Scores with each partner between Periods. The Alternate Hypothesis is: Mean Lumber Discrepancy Scores with each partner differ between Periods.

Table 3 presents partner-specific results of the test of significantly different Lumber Discrepancy Scores between Policy Periods. There is significant differences in

Discrepancy Scores between Policy Periods at the 95% confidence level with Australia, the European Union, India, Japan, Korea, Malaysia, Singapore, Taiwan, and Thailand. These findings are consistent with previous visual interpretation of Partner-specific Discrepancy Scores Figures discussed in View 4.

Only China, India and the United States do not have a significant reduction in Discrepancy risk levels during the period studied, which leaves the United States as the only nation with a national timber import policy in place that did not see a significant reduction in extreme Discrepancy Scores.

Perhaps of greatest concern from a timber legality perspective are China and India. Both are very large nations with a growing consumer class and increasing demand for primary timber products. China has a large manufacturing and re-export sector and domestic harvest restrictions (Delang & Wang 2013; Ren 2015) and India faces limitations in domestic timber supply (Norman & Canby 2020). Neither India nor China implements a timber import restriction. In China's case, these test results coupled with Figure 21 from View 4 give no indication of decreasing risk in lumber imports from Indonesia. Lumber Discrepancies with India is perhaps most concerning: Figure 23 shows a steady rise in Lumber Discrepancy Scores with India since 2006 and a plateau in the high risk range from 2013-2019. This trend is unique among the Partners studied, becoming more extreme while the majority of Partners show a reduction in extreme scores during the same period.

A Tukey HSD Test was conducted on Discrepancy Scores with India alone. Results are in Table 6 and Figure 33 presents 95% confidence intervals for each period comparison. There are significant differences in Discrepancy Scores between periods 1 and 3 ($p = 0.0005$), 1 and 4 ($p = 7.7 \times 10^{-6)}$, and 2 and 4 ($p = 0.0167$). Combining these results with interpretation of Figure 23 leads to the conclusion that Lumber Discrepancies between Indonesia and India grew more extreme over the study period. This trends in the opposite direction from all other Partners accepting China and is cause for concern of increased illegality in this timber trade partnership.
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Test Series 3 Summary Observations and Conclusions

The United States is the only nation with an import policy that has not seen a statistically significant reduction in Lumber Discrepancy Scores from 2000 - 2019.

The most concerning patterns in Lumber trade with India and China: China as a consistent, high-risk Lumber trade Partner, and India as an emerging market for risky Lumber imports.

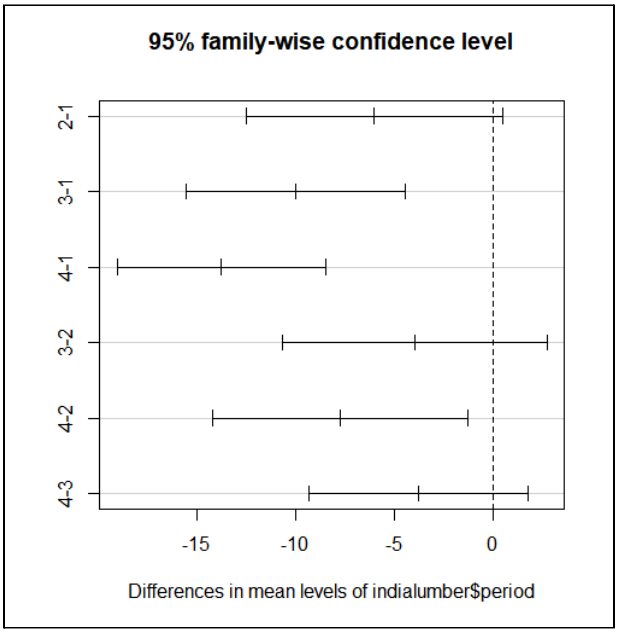
Table 5: Test Series 3 ANOVA Results

Test Series 3: ANOVA Tests Effect of Time Period on Mean Lumber Discrepancy Scores by Partner					
Partner	**Df**	**Sum Sq**	**Mean Sq**	**F value**	**Pr(>F)**
Australia	3	186.06	62.01	9.7525	0.0007
China	3	17.75	5.98	1.8521	0.1784
EU 28	3	79.69	26.56	4.3005	0.0210
India	3	611.21	203.74	19.8000	1.24E-05
Japan	3	707.15	235.72	87.2120	3.96E-10
Korea	3	670.56	223.52	86.2230	4.31E-10
Malaysia	3	493.70	164.57	7.0781	0.0030
Singapore	3	348.70	116.23	3.5025	0.0400
Taiwan	3	54.01	18.00	5.6499	0.0078
Thailand	3	200.70	66.90	13.5920	0.0001
USA	3	24.73	8.24	1.3568	0.2916

Table 6: Test Series 3 Tukey HSD Results

Test Series 3: Tukey Results on Time Periods for Lumber Discrepancies with India					
Partner	**Periods Compared**	**Difference**	**Lower**	**Upper**	**Adjusted p-value**
India	2-1	-6.023	-12.51	0.47	0.07372
	3-1	-9.984	-15.54	-4.43	0.00051
	4-1	-13.776	-19.07	-8.48	7.70E-06
	3-2	-3.961	-10.66	2.74	0.3602
	4-2	-7.753	-14.24	-1.26	0.01668
	4-3	-3.792	-9.35	1.77	0.24646

Figure 33: Tukey HSD India Lumber Time Periods Comparison



Test Series 4: T-Tests on Indonesia Policies, Lumber Only & All Partners

Test Series 4 is a comparison of Lumber Discrepancy Scores with before and after Indonesia's 2005 Enforcement Order and 2013 adoption of SVLK. Unlike the Policy Periods employed in Test Series 1-3, Series 4 applies a separate two-sample t-test with unequal variance with the null hypothesis for each of these policies: There is no difference in mean Lumber Discrepancy Scores between Indonesia and the aggregated sum of trade Partners before and after a given policy event. The Alternate Hypothesis is: Mean Lumber Discrepancy Scores differ before and after a given policy event.

Results from these t-tests are found Table 7, and Figures 34 and 35 display the ranges of Discrepancy Scores before and after the 2005 Enforcement Order and 2013 SVLK policies, respectively. Discrepancy Scores differ significantly before and after the 2005 Order ($p = 0.0004$) and 2013 SVLK Implementation (3.79×10^{-5}), and Figures 34 and 35 indicate the direction of difference is toward less extreme Discrepancy Scores. Therefore, Indonesia's Lumber Discrepancy Scores grew less risky after these significant policy adoptions. While it cannot be said with certainty that these policies drive the risk reduction, the association is clear and supported the Test Series 2 results which found that trade with all Partners, but India and China had significantly less extreme Lumber Discrepancy Scores from the beginning to end of the study.

Test Series 4 Summary Observations and Conclusions

Indonesia's Lumber Discrepancy Scores are significantly less extreme after the 2005 Enforcement Order and 2013 SVLK Implementation.

Table 7: Test Series 4 T-Test Results

Test Series 4: t-tests on Effects of Indonesia Policies on Lumber Discrepancy Scores Across All Partners						
Country	**Policy / Year Tested**	**Df**	**t score**	**Lower**	**Upper**	**p-value**
Indonesia	Enforce Order / 2005	113	-3.65	-4.8	-1.42	0.0004
Indonesia	SVLK / 2013	127	-4,27	-5.01	-1.84	3.79E-05

Figure 34: Discrepancy Score Ranges Before & After 2005

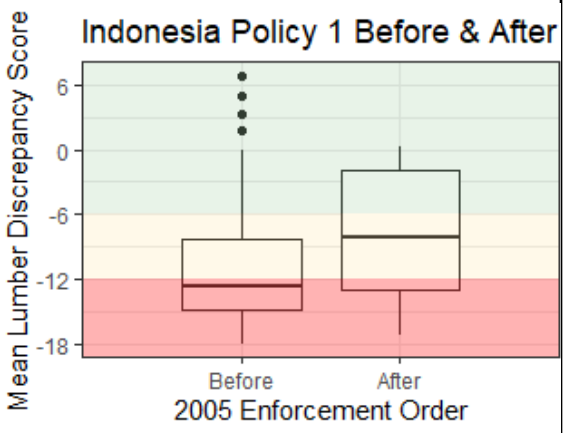
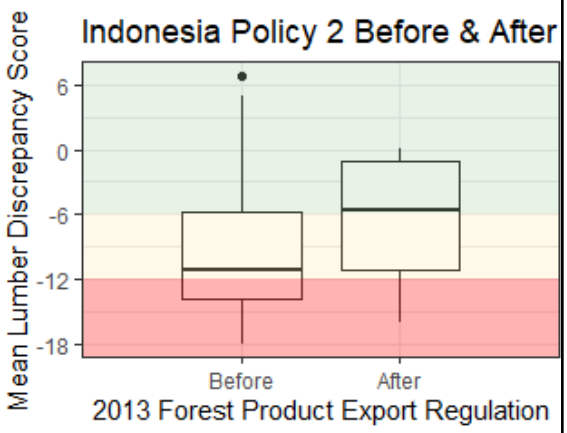


Figure 35: Discrepancy Score Ranges Before & After 2013



Test Series 5: T-Tests on Partner Policies, Lumber Only

Test Series 5 turns to specific import policies adopted by Indonesia's trade Partners. The one or two most relevant policies for each nation are included in this test series. These policies are noted with a “y” in Appendix 2 under the column labeled “t-test”. Each of the rows in Table 5 displays results of a distinct two-sample t-test with unequal variance of Lumber Discrepancy Scores before and after a Partner’s specific policy event. The Null Hypothesis for each test is: There is no difference in mean Discrepancy Score before and after a given policy takes effect. The Alternate Hypothesis is: Mean Discrepancy Scores differ before and after a given policy takes effect. Figures 36 - 44 show Lumber Discrepancy Score ranges before and after each Partner’s policy event.

Except for Malaysia and the United States, each national timber import policy tested has statistically significant differences before and after implementation. Comparing these

test results with their corresponding Figures below, it is clear that each of these significant test results corresponds with a decrease in extreme discrepancies.

As exceptions to the pattern of reduced Discrepancy extremes, Malaysia and the United States warrant further discussion. Referring to Figure 26, Malaysia's Lumber Discrepancies do grow less extreme over the study period, but this trend does not begin until 2005, the year of Indonesia's Enforcement Order on timber illegality. The data clearly show this trend, but it cannot be concluded whether Malaysia policy was ineffective, or whether the combination of Import and Export policies were instrumental in the risk reduction. However, this result does appear to concur with Obidzinski et al. (2007), who state that over-border smuggling of illegal timber was likely overestimated, and other forms of domestic illegality underestimated in the early 2000s in Indonesia. This interpretation is further supported by the fact that Indonesia's log export ban in 2001 and lumber export ban in 2004 are not obviously associated with reduction in extreme discrepancies until after the 2005 Enforcement Order. It stands to reason that Malaysia's ban on log and lumber imports from Indonesia could be effective only with a meaningful Indonesian enforcement regime. This case provides evidence that bilateral policies may be an effective way to reduce timber illegality risk between specific trade partners.

The case of Lumber Discrepancies with the United States is unique in that extreme Scores appear to grow from 2009 to 2019 despite the expansion of the Lacey Act amendment to include wood products in 2009, as seen in Figure 30. Therefore, USA's lumber imports from Indonesia remain a moderate and possibly growing risk, despite the Lacey Act amendment.

Test Series 5 Summary Observations and Conclusions

Risk of illegality in Indonesian Lumber imports is reduced after adoption of national timber import policies by Australia, the European Union, Japan, Korea, and Taiwan. It cannot be concluded that any specific policy causes this risk reduction, and combined with results from Test Series 4, believe there is strong evidence suggesting that bilateral timber legality policy may be the best, if not a perfect, predictor for reducing timber trade illegality.

The US Lacey Act is not associated with a reduction in Lumber Discrepancy Scores, and the Lumber trade between the USA and Indonesia is of consistently moderate and possibly growing risk since Lacey implementation.

Test Series 5: t-tests on Effects of Partner Policies on Lumber Discrepancy Scores with Indonesia						
Partner	**Policy / Year Tested**	**Df**	**t score**	**Lower**	**Upper**	**p-value**
Australia	ILPR / 2014	5.65	-6.36	-10.54	-4.62	9.00E-04

EU 28	FLEGT / 2013	5.11	-2.59	-8.37	-0.05	0.0481
Japan	Goho / 2006	7.16	-11.80	-14.80	-9.88	5.93E-06
Japan	CWA / 2017	17.90	-3.63	-8.80	-2.34	0.00195
Korea	ASUT / 2012	13.13	-5.01	-11.80	-4.68	2.31E-04
Korea	ASUT amend / 2018	16.39	-4.34	-10.60	-3.66	4.81E-04
Malaysia	Import Ban / 2003	3.72	-0.91	-17.96	9.31	0.419
Taiwan	FTA / 2010	17.97	-2.35	-4.14	-0.23	0.0305
USA	Lacey / 2009	13.22	-0.14	-2.81	2.46	0.889

Figure 36: Australia Lumber Discrepancy Scores Before & After 2014 ILPR

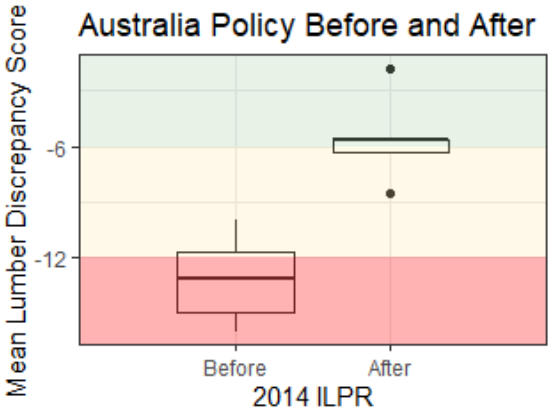


Figure 37: EU Lumber Discrepancy Scores Before & After 2014 VPA Implementation

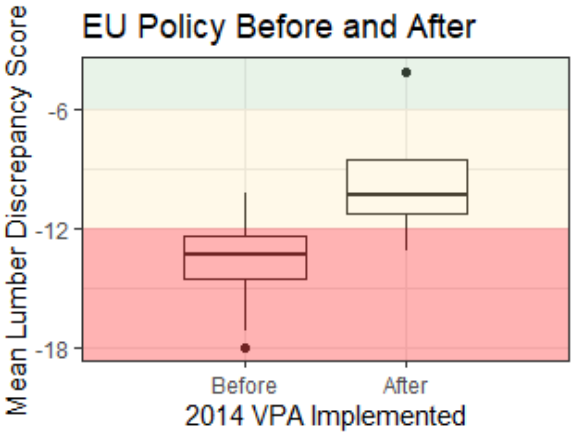


Figure 38 : Japan Lumber Discrepancy Scores Before & After 2006 Goho Wood

Figure 39: Japan Lumber Discrepancy Scores Before & After 2017 Clean Wood Act

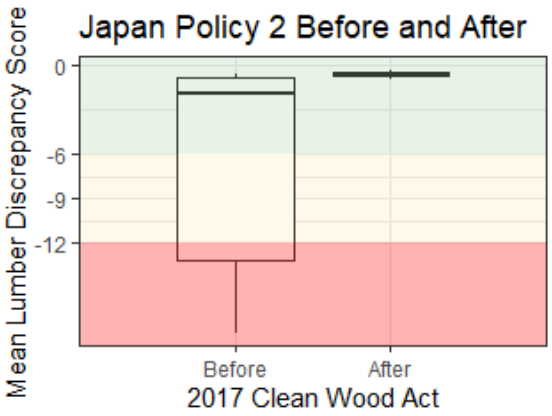


Figure 40: Korea Lumber Discrepancy Scores Before & After 2012 ASUT

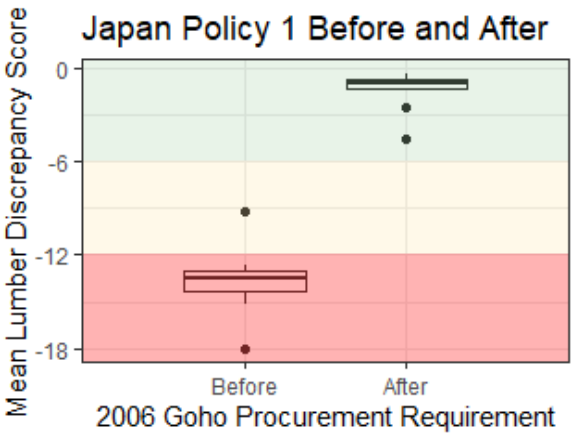


Figure 41: Korea Lumber Discrepancy Scores Before & After 2018 ASUT Amendment

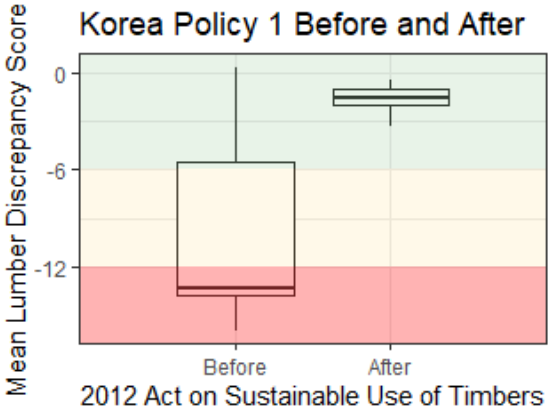


Figure 42: Malaysia Lumber Discrepancy Scores Before & After 2002-03 Bans

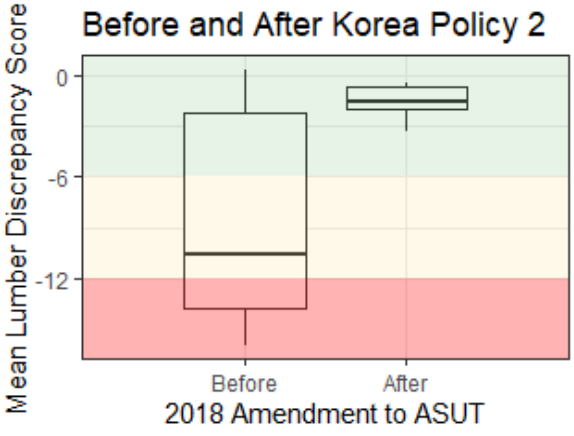


Figure 43: Taiwan Lumber Discrepancy Scores Before & After 2010 FTA Amendment

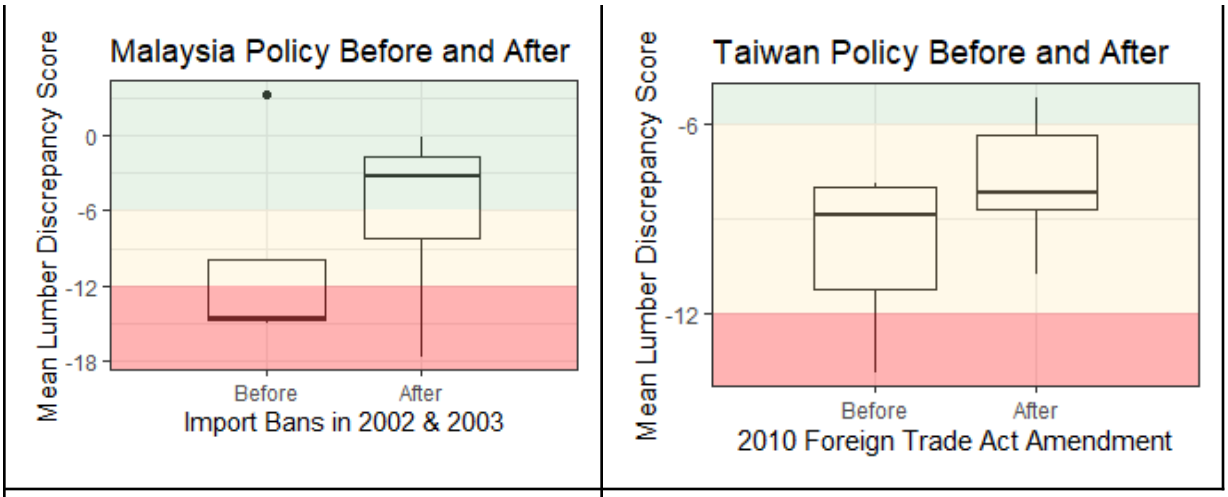
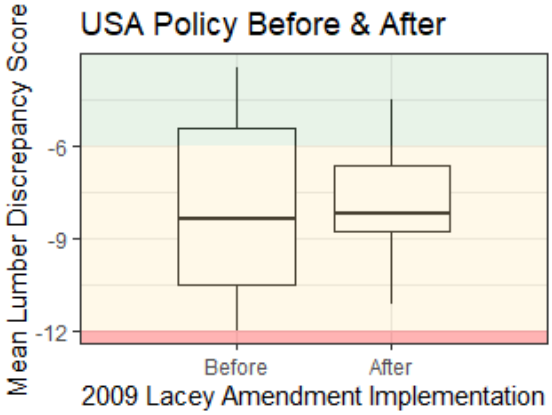


Figure 44: Taiwan Lumber Discrepancy Scores Before & After 2009 Lacey Implementation



Test Series 6: T-Tests on No-Policy partners

The final Test Series mirrors Series 4, which looked at Lumber Discrepancy Scores before and after Indonesian policy events for the aggregate of all partners. Test Series 6 applies t-tests around the same dates (2005 Enforcement Order and 2013 SVLK Implementation) to test for difference in Lumber Discrepancy Scores with Partners lacking timber import policies, before and after Indonesia's policy implementation. The Null hypothesis for each of the following tests is: There is no difference in Lumber Discrepancy Scores between Indonesia and a given Partner before and after a given Policy. The Alternate Hypothesis is: Discrepancy Scores differ before and after a given Policy. Each row in Table 5 reports results from a separate two-sample t-test with

unequal variance, and Figures 45 - 52 chart the mean Lumber Discrepancy Score ranges with each Partner before and after each policy.

Lumber Discrepancies with China do not differ significantly before and after the 2005 Order but are significantly different before and after Indonesia's 2013 SVLK implementation ($p = 0.0299$). Despite this significant result, visual interpretation of Figure 21 makes clear that Lumber trade between Indonesia and China remains at a moderate to high risk level and must be considered as Indonesia's trade Partner with highest risk of illegality.

Lumber Discrepancy Scores with India differ significantly before and after Indonesian policies in 2005 ($p = .0023$) and 2013 ($p = 5.65 \times 10^{-5}$). As identified through Test Series 3 and Figure 23, the trend in India is toward increasingly extreme Lumber Discrepancy Scores, a trend which only the USA also exhibits as identified through analysis of Test Series 5 and Figure 30.

Test Series 6: t-tests on Effects of Partner Policies on Lumber Discrepancy Scores with Indonesia

Partner	Policy / Year Tested	Df	t score	Lower	Upper	p-value
China	Enforce Order / 2005	6.66	-0.08	-2.87	2.68	9.38E-01
China	SVLK / 2013	12.36	-2.45	-3.52	-0.21	0.0299
India	Enforce Order / 2005	6.98	4.66	5.29	16.22	0.0023
India	SVLK / 2013	15.13	5.52	5.48	12.40	5.65E-05
Singapore	Enforce Order / 2005	6.77	0.29	-8.56	10.95	0.7788
Singapore	SVLK / 2013	13.79	-3.07	-12.99	-2.29	0.0085
Thailand	Enforce Order / 2005	7.75	-4.19	-9.36	-2.69	0.0033
Thailand	SVLK / 2013	13.13	-4.16	-6.63	-2.10	0.0011

Figure 45: China Lumber Discrepancy Scores Before & After 2005 Enforcement Order

Figure 46: China Lumber Discrepancy Scores Before & After 2013 SVLK Implementation

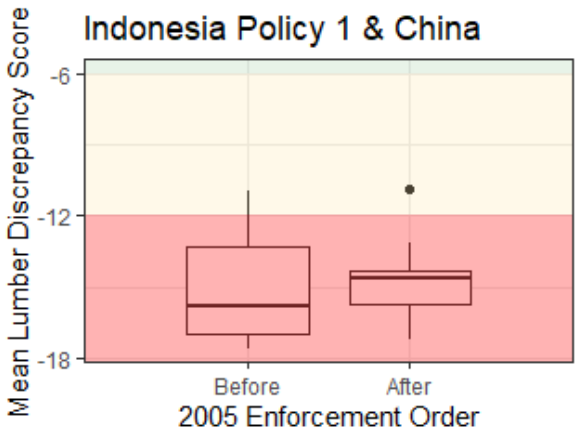


Figure 47: India Lumber Discrepancy Scores Before & After 2005 Enforcement Order

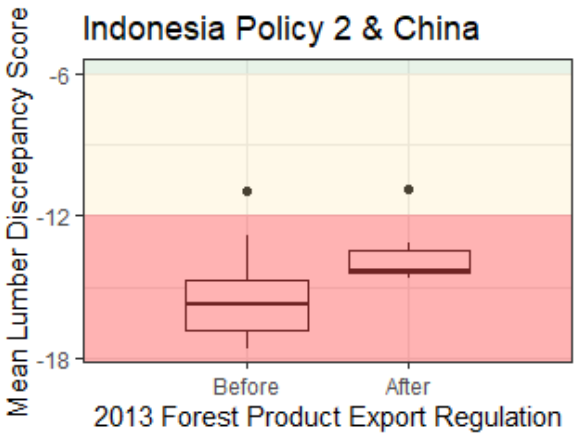


Figure 48: India Lumber Discrepancy Scores Before & After 2013 SVLK Implementation

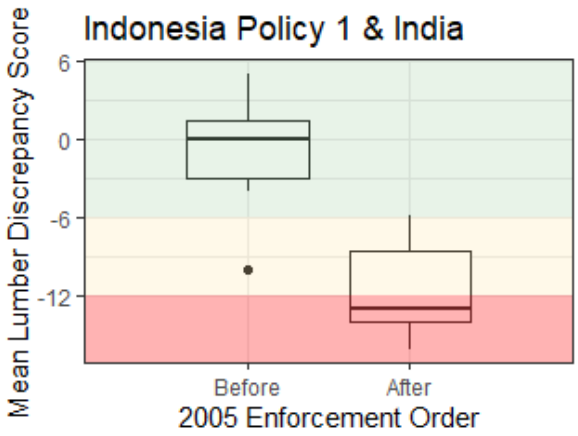


Figure 49: Singapore Lumber Discrepancy Scores Before & After 2005 Enforcement Order

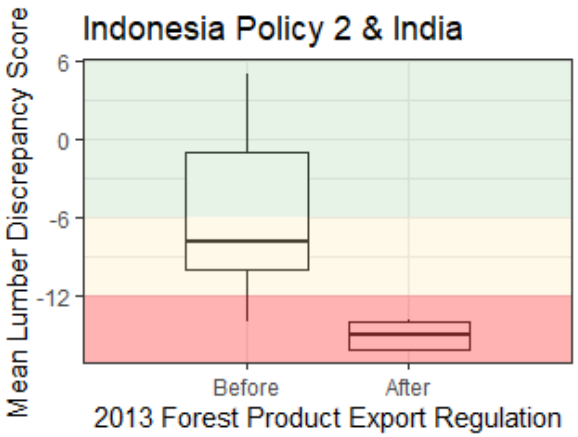


Figure 50: Singapore Lumber Discrepancy Scores Before & After 2013 SVLK Implementation

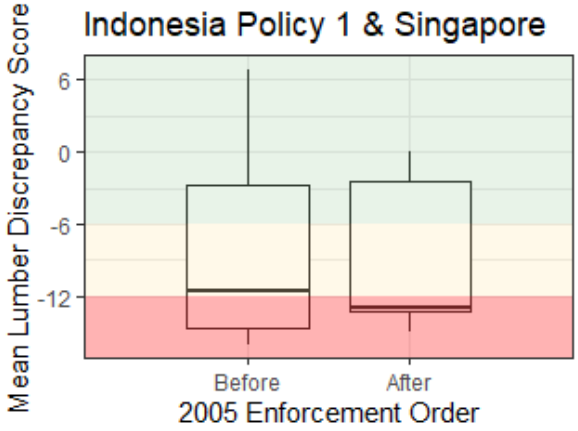


Figure 51: Thailand Lumber Discrepancy Scores Before & After 2005 Enforcement Order

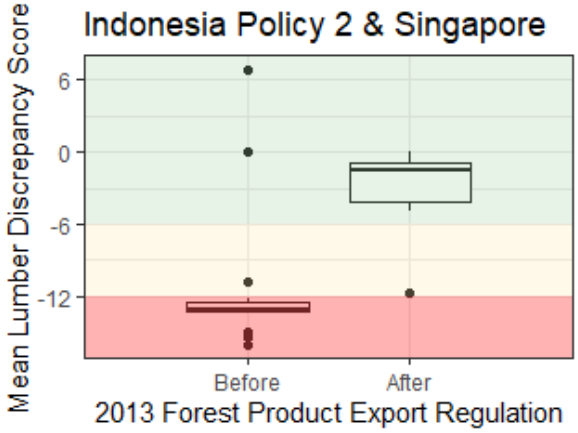
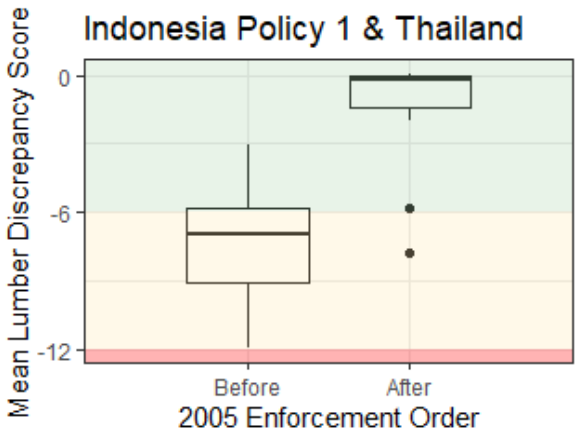
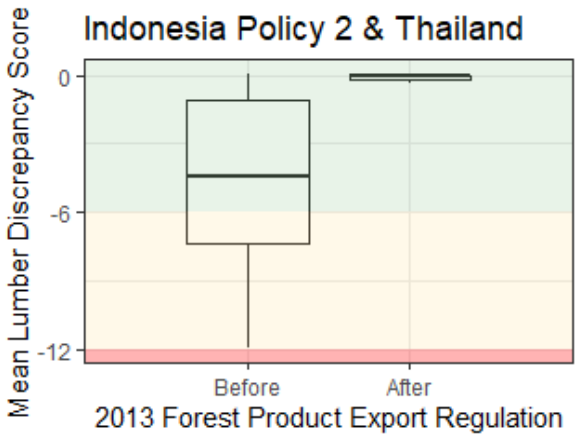


Figure 52: Thailand Lumber Discrepancy Scores Before & After 2013 SVLK Implementation





Section 7. Conclusion

This study began with three research questions, which are now used to organize discussion of findings and conclusions.

How effective are national policies at curbing Indonesian illegal timber trade?

This research does not permit us to isolate the effects of Indonesia's policies versus partner policies and other external factors. However, this research does provide evidence of association between both exporter and importer policies.

Indonesia's 2005 Enforcement Order and 2013 SVLK policies each preceded significant decreases in extreme Discrepancy Scores and therefore risk of illegal timber trade (Test

Series 4). Discrepancy Scores for trade of Lumber with all partners decreased significantly over the study period (Test Series 2). There has been a lasting decline in extreme scores following the 2005 policy with Japan, Korea, Malaysia, Taiwan, and Thailand (Test Series 3 and Appendix 3 “Lumber”). The decline in extreme scores appears to have been short-lived in Australia (Lumber), China (Logs, Lumber), the EU (Lumber), and the United States (Lumber) (Appendix 3, “Lumber”). Following SVLK implementation from 2014 to 2019, Lumber Discrepancy Scores grew less extreme in Australia, the EU, and Singapore (Appendix 3, “Lumber”). During the same period, Scores with China remained high and scores with India and the United States grew (Test 3, Appendix 3). Despite these exceptions, Indonesia’s Discrepancy Scores grow significantly less extreme over the course of the study (Test Series 1). As Discrepancies are widely thought to contain illegality, this research provides evidence that Indonesia’s national efforts at reducing timber illegality have proven effective at reducing but not eradicating the problem.

Trade Partner Policies appear meaningfully linked to declines in Lumber Discrepancy Scores as well, and this research provides evidence to suggest that the combination of Importer and Exporter policies may be most effective in driving a lasting reduction in Discrepancies. Discrepancy Scores with Indonesia declined after timber import policy events in Australia (2014), the EU (2013), Japan (2006 and 2017), Korea (2012 and 2018), and Taiwan (2010) (Test Series 5). These results may be particularly relevant to policy evaluation efforts and efficacy reviews from the European Union (European Commission 2020), Australia (ADAWR 2018), and United States (Prestemon 2015) governments and NGOs (EIA 2021; Logging Off 2021).

Notable exceptions to the pattern of declining discrepancies are Malaysia, which saw a rise in Scores after its 2002 and 2003 bans on Indonesia Logs and Lumber; but this was followed by a lasting decline following Indonesia's 2005 Enforcement Order, lending support to the finding that bilateral policy appears to have a lasting effect of reducing Discrepancies.

The USA is a second exception, where Lumber Scores rise steadily in the years following the 2009 expansion of the Lacey Act Amendment to wood products. There is evidence that the Lacey Act is only national timber import policy not tied to a significant decline in Discrepancy Scores (Test Series 5), though this data do not provide a much insight into the cause of this trend. The two most plausible (but not exclusive) explanations seem to be that either the Lacey Act has not been effective at reducing Discrepancies related to illegal trade, or that Discrepancies in United States timber imports from Indonesia are driven by factors other than illegality. While this analysis is not able to pinpoint the magnitude of risk reduction due to each given policy, it is likely that separate and combined effects of export and import policies as important factors to that risk reduction.

While total Lumber Discrepancies grow less extreme over the study, and most national policies are linked with this trend at the national level, this research also uncovers

reason for concern that national policies may drive leakage to unregulated timber markets.

Which specific Partners and Products exhibit the highest risk of illegal timber imports from Indonesia?

Views 1 and 3 clearly establish that Lumber is responsible for the most extreme Discrepancy Scores in Indonesian timber trade. While most timber import policies are linked with a trned of decline in total Lumber Discrepancies over the study period, there is also evidence that national timber import regulations may drive leakage to less regulated markets.

China's Lumber Discrepancy Scores remain stubbornly high throughout the study period and show a significant decline only from extreme to moderate risk after Indonesia's implementation of SVLK in 2013 (Test Series 6 and Appendix 3). Log Discrepancies with China also appear more extreme than with any other nation, and 2012 to 2016 saw a period of extreme Discrepancies in Chinese Plywood imports (Appendix 3). Given that China is the second largest import of Indonesian Timber products (Figure 2) and shows the most extreme Discrepancies in all three Product categories studies, China is Indonesia's timber trade partnership at highest risk of illegality. There is hope that China will complete the effort of enacting long-awaited timber import regulations (Yin 2020; Norman & Saunders 2017) to reduce trade Discrepancies and reduce opportunities for leakage.

India, though only the twelfth largest export destination for Indonesia timber (Figure 2) is a growing market with increasing demand for timber imports (Norman & Canby 2020) with no timber import policy (Director general of Foreign Trade 2015; Norman & Canby 2020 2020). The pattern of steadily increasing Lumber Discrepancies with India (Figures 47 and 48; Test Series 6) concurrent to steady decreases among Partners with import regulations (Test Series 5) is reason to believe that India may be a growing risk as illegal trade leaks from regulated to unregulated markets.

The United States is the third largest export destination for Indonesia timber (Figure 2) and is an anomaly in this data for its increasing Lumber Discrepancy Scores since 2009 despite Lacey Act expansion to include wood products in 2009 followed by high profile enforcement cases. This analysis does not permit greater insight into this dynamic, but the trend identified is surely of interest to regulators, timber producers whose profits may be impacted by illegal timber products entering the USA, and consumers who wish to avoid negative environmental impacts.

How effective is Discrepancy Analysis for identifying illegality in timber supply chains?

Discrepancy Analysis of trade data reported in HS Codes is a valuable but coarse tool for estimating presence and magnitude of illegal trade. This reesarch enabled identification of broad trends but is not suited to gaining detailed insight into shorter-term fluctuations and therefore only able to investigate approximate

relationships between effects of policy on timber trade discrepancies. Further, discrepancies, though widely agreed to contain legality, are inherently opaque and isolating illegality from other “normal” sources of difference between importer and exporter reporting is a matter of estimation and assumption. Further, this particular analysis was limited to annual data, which rendered statistical tests and policy timelines somewhat coarse; quarterly or monthly data would be an improvement. Discrepancy Analysis in search of illegality benefits from finer levels of details in the data wherever possible. The ability to “slice” data by Partner and Product, to overlap policies and construct Policy periods, has greatly improved the information gleaned from otherwise rather blunt data.

Despite shortcomings, this research has successfully identified several trends not identified in literature review. That lumber is a higher risk product that logs or plywood had not, to the author’s knowledge, been previously identified. This project also provides evidence of illegal product leakage from more to less regulated markets in the cases of India and China. This is deserving of additional study, and if validated should concern policymakers, timber producers, and environmental NGOs alike. This project has also shown that the United States has not seen a consistent reduction in extreme Discrepancies for Indonesian timber imports, giving reason to question the efficacy of Lacey Act expansion on preventing illegal timber from interesting American markets.

Further Research

Further work to quantify sources of normality more precisely in discrepancies would enable a clearer parsing of illegal or risky discrepancies.

Understanding this data to be non-normally distributed, future application of nonparametric statistical testing would be a valuable contribution and may increase the confidence in conclusions about legality risk.

Additional research on the presence and magnitude of leakage resulting from specific policies will be vital to ongoing efforts to reduce tropical forest loss resulting from illegal trade. This research might focus on India and China as of particular risk for illegal timber imports.

Analysis of a broader range of products linked to forest loss, especially pulp and paper and palm oil in the case of Indonesia, would be very valuable to assess the level of illegality across a complete set of forest-dependent commodities. This could also expand on the leakage issues identified here, adding to the discussion the dimension of leakage across commodities.

Additional research could seek to understand the cause of disproportionate shares of Discrepancy Scores among regional partners compared to shares of export value (as discussed in View 1).

Appendix 1: HS Code C4 Product Category Sorting

Hardwood Logs	Hardwood Lumber	Hardwood Plywood	OSB and Waferboard	Particleboard	Softwood Logs
440312	440721	441210	441012	441011	440310
440331	440722	441213	441019	441031	440311
440332	440723	441214	441021	441032	440320
440333	440724	441222	441029	441033	440321
440334	440725	441223		441039	440322
440335	440726	441224			440323
440341	440727	441229			440324
440349	440728	441231			440325
440391	440729	441232			440326
440392	440790	441233			
440393	440791	441234			
440394	440792	441292			
440395	440793	441293			
440396	440794	441299			
440397	440795				
440398	440796				
440399	440797				
	440798				
	440799				

Softwood Lumber	Softwood Plywood	Temperate Hardwood Lumber	Tropical Hardwood Lumber	Wood Furniture
440710	441219	440790	440721	940161
440711	441239	440791	440722	940169
440712		440792	440723	940330
440719		440793	440724	940340
		440794	440725	940350
		440795	440726	940360
		440796	440727	
		440797	440728	
		440799	440729	

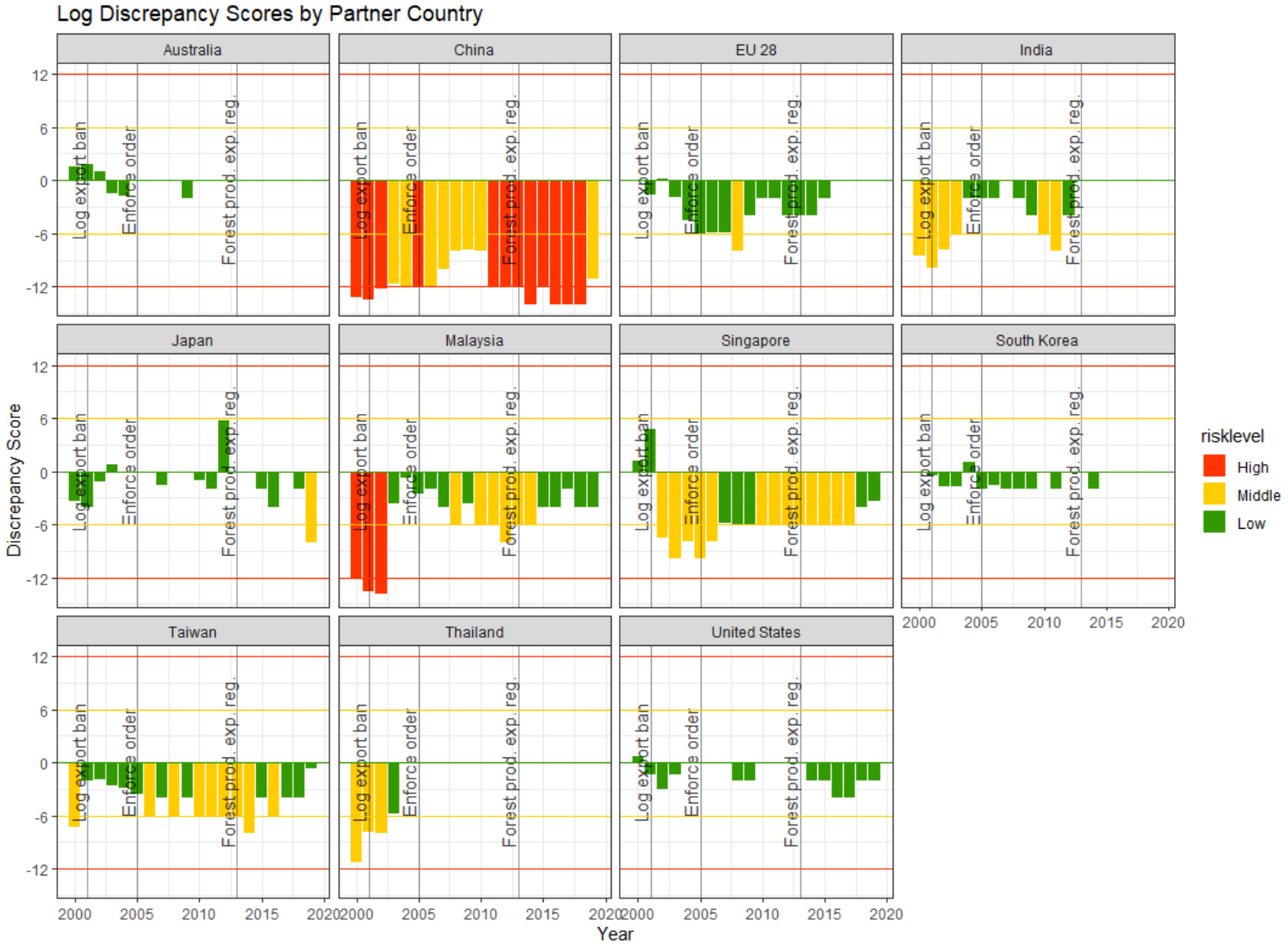
Appendix 2. Policy Dates for Analysis

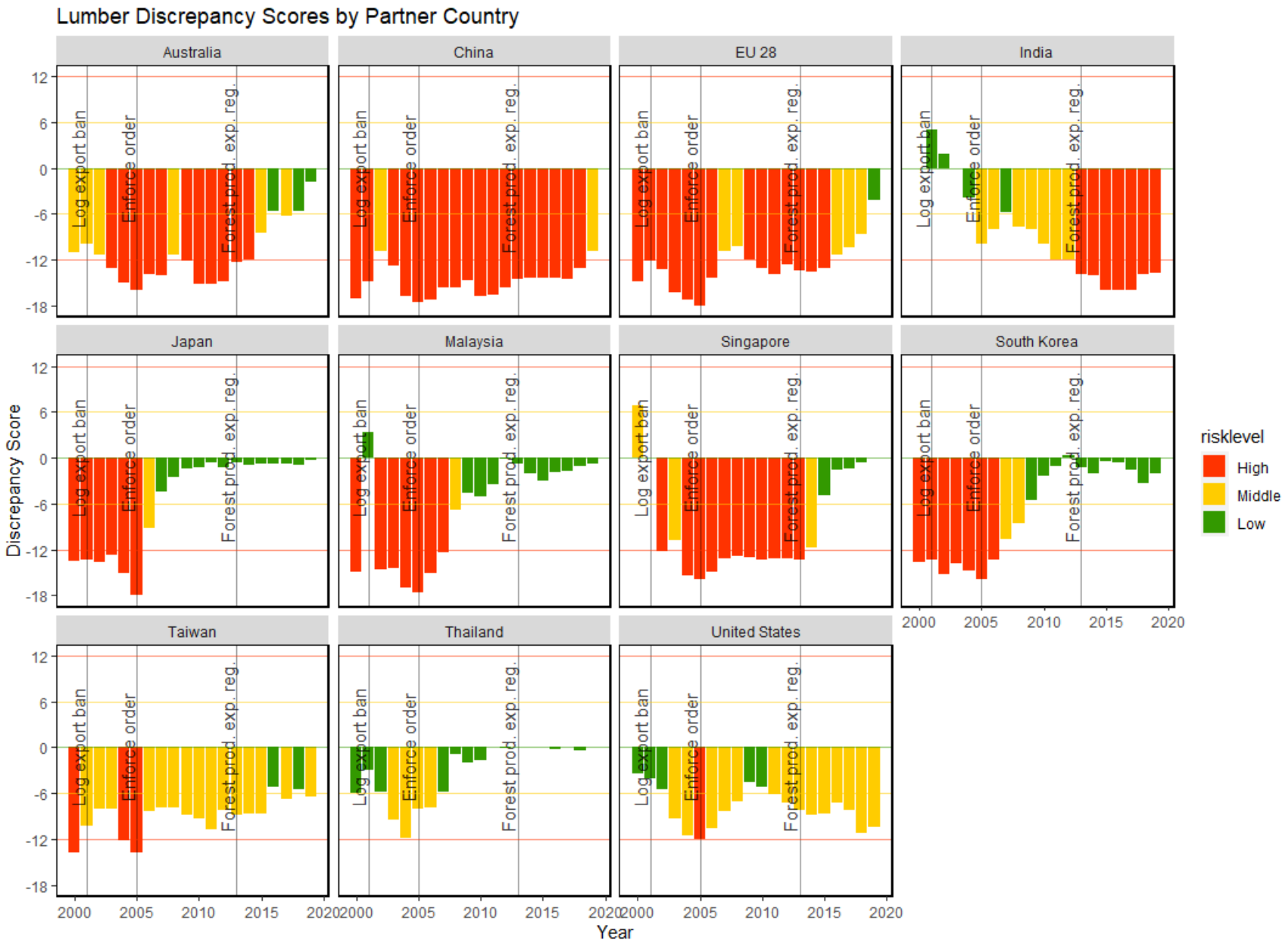
Country	Year	Policy Name	t-tests?	Notes
Australia	2012	ILPA	n	Illegal Logging Prohibition Act obligation that importers meet legal restrictions
Australia	2014	ILPR	y	Illegal Logging Prohibition Regulation implements ILPA
Australia	2018	CSG	n	Country-Specific guidelines co-signed by both nations
China	1999	Domestic forest policies	n	1. Natural Forest Protection Program: reduces state-owned natural forest logging (w/ exceptions). 2. Slope land conversion program: market incentives for private sustainable management
China	2017	Logging ban	n	Full ban of domestic logging in state-owned natural forests.
China	2019	Forest law amendment	n	Enacts responsibility on importers to identify illegal product
EU 28	2010	EUTR	n	European trade Regulation enacts importer responsibility to eliminate illegal timber
EU 28	2014	VPA Indonesia	y	VPA implemented with Indonesia
EU 28	2016	FLEGT license	y	EU Forest Law Enforcement, Governance and Trade Licensure. Licensing began Nov.2016 so analysis uses 2017 for before/after.
India	2003	Plant Quarantine Order	n	Specifies plant species and products may be imported into India
Indonesia	2001	Log export ban	n	Covers all roundwood exports
Indonesia	2005	Enforce order	y	Yudhoyano mandates strict enforcement of timber laws
Indonesia	2013	Forest prod. exp. reg.	y	Regulations to enforce implementation of TLAS / SVLK (from 2009)

Appendix 2. Policy Dates for Analysis

Japan	2000	Sustainable Procurement	n	Does not yet include wood products
Japan	2006	Goho Wood	y	Wood products added to public procurement requirement
Japan	2017	Clean Wood Act	y	Voluntary sustainable timber standards enacted 2016, implemented 2017
Malaysia	2002	Log import ban	y	Ban on Indonesian roundwood imports
Malaysia	2003	Sawnwood import ban	y	Adds squared logs >60 in sq to import ban
South Korea	2012	Sustainable timber act	y	Enacted, no timeline or regulatory framework
South Korea	2018	Sustainable timber amend	y	Mandatory implementation regs for Act on Sustainable Use of Timbers. Prohibits sale of unverified timber in Korea.
Taiwan	2010	Foreign trade act amend	y	Enacts & Implements standards to meet CITES
Taiwan	2014	Wildlife conservation act	n	Updates new CITES listings
Thailand	2013	EU VPA Sign	y	VPA signed 2013
Thailand	2017	EU VPA negotiation	n	VPA negotiations begin
United States	2009	Lacey Act	y	Lacey act amendment 2008, Wood HS codes added 2009
United States	2012	Gibson Guitars	n	Gibson: $350K cash & comm. service, compliance program, forfeit illegal assets
United States	2016	Lumber Liquidators	n	Lumber liquidators $13M criminal fines & comm. service, forfeit illegal assets

Appendix 3. View 3, Product View




Lumber Discrepancy Scores by Partner Country
Australia
China
EU 28
India
Japan
Malaysia
Singapore
South Korea
Taiwan
Thailand
United States
Log export ban
Enforce order
Forest prod. exp. reg.
Discrepancy Score
Year
risklevel
High
Middle
Low


Plywood Discrepancy Scores by Partner Country
Australia
China
EU 28
India
Japan
Malaysia
Singapore
South Korea
Taiwan
Thailand
United States
Log export ban
Enforce order
Forest prod. exp. reg.
Discrepancy Score
Year
risklevel
High
Middle
Low

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