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Examining the connection of money laundering and environmental crime: A deep dive into dirty money and trade

(iD) **Nur Liyana Mohamed Yousop**[1+]
(iD) **Nazrul Hisyam Ab Razak**[2]
(iD) **Bany Ariffin Amin Noordin**[3]

[1]*Faculty of Business and Management, Universiti Teknologi MARA, Johor Branch, Segamat Campus, Malaysia.*
[1,2,3]*School of Business and Economics, Universiti Putra Malaysia, Malaysia.*
[1]*Email:* nurliyana@uitm.edu.my
[2]*Email:* nazrul@upm.edu.my
[3]*Email:* bany@upm.edu.my

(+ Corresponding author)

ABSTRACT

This study explores current research trends on Trade-Based Money Laundering (TBML) within the context of environmental crime through a structured review of academic literature. It then investigates the association between TBML and environmental crime incidents across Southeast Asia. A two-stage methodology is adopted. The first stage systematically reviews studies published between 2006 and 2025, revealing that TBML research remains in its infancy and is principally focused on conceptual frameworks with limited empirical validation. The second stage applies a fixed-effects panel regression, using trade mis invoicing as a proxy for TBML and controlling for corruption, government intervention, and cross-border mobility. The results indicate a positive and statistically significant association between TBML and environmental crime, with the relationship strengthened in jurisdictions marked by higher levels of corruption and weaker enforcement. These findings underline the necessity for coordinated regional action and a holistic policy response to all TBML dimensions. Policymakers should conduct a comprehensive review of Southeast Asian regulatory frameworks to close loopholes, strengthen cross-border cooperation, and deploy real-time fraud detection systems to enhance transparency and deter illicit conduct. Enforcement must remain proportionate to avoid displacing laundering into clandestine channels, striking a balance between vigilant oversight and the facilitation of legitimate trade.

Contribution/Originality: While money laundering has been widely studied, focused research on TBML concerning environmental crime is limited. This study addresses that gap through a structured review and empirical analysis centered on Southeast Asia, offering new insights into TBML research.

1. INTRODUCTION

Money laundering poses a significant threat to global economic stability and sustainable development, with estimates suggesting it accounts for between two and five percent of global GDP, or roughly eight hundred billion to two trillion dollars annually (Camdessus, 1998; Ferwerda, 2017). This illicit activity obscures the origins, ownership, and destinations of illegally acquired funds, transforming them into legitimate transactions (Otusanya & Adeyeye, 2022; Schroeder, 2001). While Zdanowicz (2004) and Zdanowicz (2017) emphasize the importance of addressing money laundering at the "front door," they also draw attention to the persistent issue of illicit activities linked to international trade at the "back door" (Batayneh, Haque, Baldock, & Brewer, 2022). The complex nature of

international trade makes Trade-Based Money Laundering (TBML) the method of choice for most criminal organizations to hide their illegal proceeds. This sophisticated mechanism strategically manipulates financial instruments and banking services to integrate illegitimate capital within ostensibly legitimate commercial transactions (Batayneh et al., 2022).

The extensive networks of international trade, combined with their complex documentation, offer significant opportunities for criminals to execute Trade-Based Money Laundering (TBML) schemes undetected, facilitating large-scale money laundering through seemingly legitimate trade channels. A broad range of stakeholders, including importers, exporters, intermediaries, customs brokers, and financial institutions, participate in the trade process, and each can be exploited for TBML purposes (Masciandaro, 2013; Mavrellis, 2021a). These actors, whether intentionally or unintentionally, may help facilitate the movement of illicit funds through financial institutions, particularly in regions with weak Anti-Money Laundering (AML) regulations, thereby integrating illegal proceeds into the formal financial system (Financial Action Task Force (FATF) & Egmont Group, 2020a, 2020b; Naheem, 2017). Furthermore, launderers have diversified into non-traditional assets such as timber, animals, minerals, and fishery products, exacerbating environmental degradation and biodiversity loss (Schneider, 2010).

In Southeast Asia, the convergence of its strategic location astride the Straits of Malacca and extensive overland corridors linking emerging economies, combined with rapid economic growth and substantial trade volume, has created a fertile environment for organized crime (Organisation for Economic Co-operation and Development (OECD), 2019; United Nations Office on Drugs and Crime (UNODC), 2019). The region's abundance of environmental resources and high-value commodities such as wildlife and timber has created lucrative environmental crime markets. This is evidenced by the increase in the fauna crime index from 7.09 in 2021 to 7.23 in 2023 and the flora crime index from 5.86 to 6.18 over the same period, surpassing other Asian regions (Global Initiative Against Transnational Organized Crime (GITOC), 2021, 2023). Porous borders, limited law enforcement, and insufficient AML requirements across jurisdictions enable criminal networks to exploit free-trade zones and make use of correspondent banking relationships to transfer illicit proceeds without accompanying goods through the region's financial system (Financial Action Task Force & Egmont Group, 2020a, 2020b). By blending legitimate commodity flows with falsified trade documentation and shell companies, these organizations obscure the true origin of funds, posing substantial challenges for detection by authorities (Spapens, White, Uhm, & Huisman, 2018; Van Uhm & Nijman, 2022).

Despite the growing concerns surrounding TBML in Southeast Asia, research on the economic and financial aspects of environmental crimes, especially their connection to TBML, remains limited. While much of the existing research focuses on developing nations, Southeast Asia, where these crimes are most prevalent, has received relatively little attention (Coleman, 2022; Hansen et al., 2014; Noor, Muhamad, & Kadir, 2022). This gap underscores the necessity for more thorough research, which this study aims to fulfill.

2. CURRENT TRENDS

The primary objective of this study is to explore current research trends in TBML related to environmental crimes. To accomplish this, we conducted a targeted literature review using keywords such as "trade-based money laundering" and "environmental crime" across the Scopus and Web of Science (WoS) databases. The review period spans from July 2006, corresponding to the earliest indexed TBML publication in Scopus and the release of the FATF's first report on TBML, to May 2025. Data collection was completed on May 9, 2025. The dataset includes various scholarly outputs, such as journal articles, books, book series, review papers, and conference proceedings. These records were systematically compiled into an Excel file using CSV export formats to ensure data accuracy and consistency.

Figure 1 depicts the search strategy for TBML. At the time of data extraction, a Scopus query returned 54 articles and books. In comparison, an expanded WoS search retrieved 48 articles, with some overlap due to duplicate entries.

A major milestone in Scopus data appeared in 2006, following the FATF report, which has since become a foundational reference in TBML studies. The WoS search revealed an earlier study by Thanasegaran and Shanmugam (2007) that examined money laundering risks in Malaysian international trade, focusing on invoicing fraud and misdescription of goods. Both publications highlighted significant TBML risks, detailing methods such as trade mis-invoicing, transfer pricing, and false product descriptions. Additionally, it emphasizes the limited data availability as a barrier to fully understanding and addressing these issues.
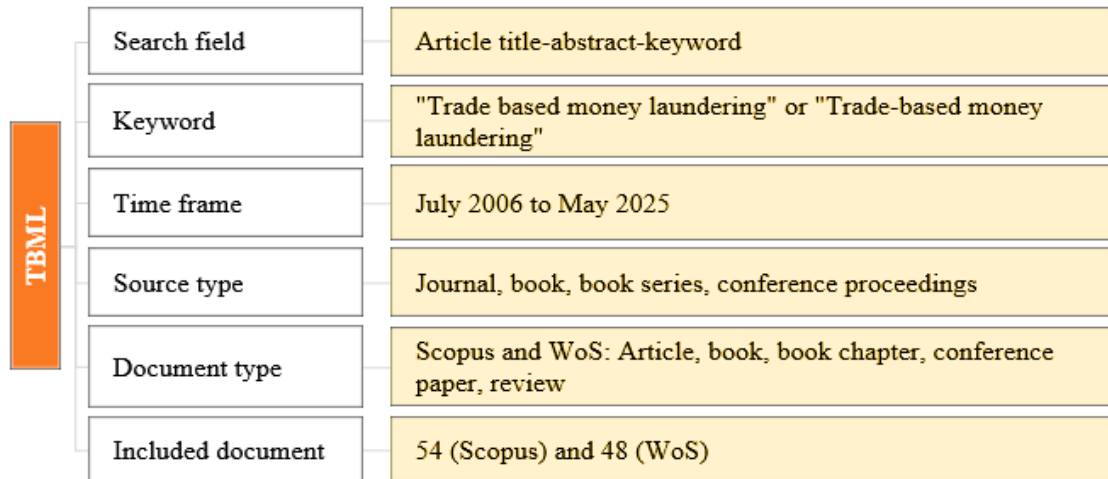
TBML	Search field	Article title-abstract-keyword
	Keyword	"Trade based money laundering" or "Trade-based money laundering"
	Time frame	July 2006 to May 2025
	Source type	Journal, book, book series, conference proceedings
	Document type	Scopus and WoS: Article, book, book chapter, conference paper, review
	Included document	54 (Scopus) and 48 (WoS)

Figure 1. The TBML search strategy.

Figure 2 presents research trends on TBML based on Scopus-indexed metrics, including total citations, h-index, g-index, and hA-index. Overall, the citation trajectory appears to fluctuate. The highest number of citations was recorded in 2020, reaching 116, along with an h-index of 4, a g-index of 5, and an hA-index of 3. However, citations declined in 2021, indicating a temporary dip in TBML-related research visibility. A modest increase followed in 2022 and 2023, before tapering off again in 2024. Although there are signs of renewed interest, citation levels remain below the earlier peaks observed in 2009 and 2019, suggesting that while scholarly engagement with TBML is recovering, it has not yet reached previous highs.
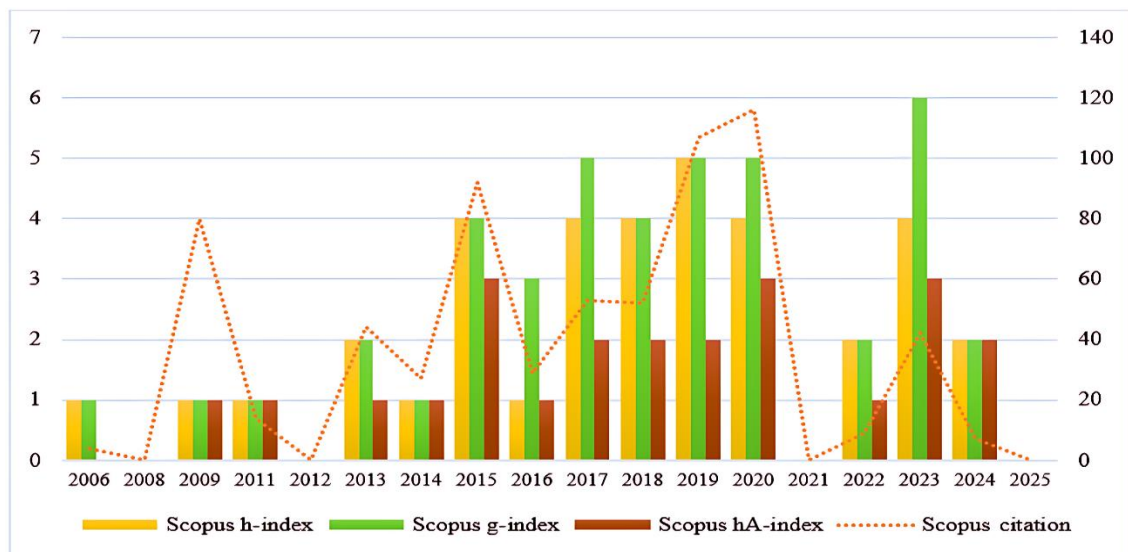

Figure 2. Citations and indices in TBML studies.

A subsequent search using "trade-based money laundering" and "environmental crime" yielded no results in either database. We therefore broadened the search to 'money laundering' paired with environmental crime

descriptors, as outlined in Table 1. This broadened search yielded 38 Scopus records published between 2006 and 2025, including items dating back to 2003, which raised the total to 40. The equivalent search in WoS returned 17 records from 2008 to 2025 and one further record from 2004, bringing the overall count to 18 documents.

Table 1. Search strings.

Database	Queries
Scopus	TITLE-ABS-KEY ("Money laundering" AND ("Environmental crime*" OR "plastic waste" OR "waste dumping" OR "illegal waste" OR "wildlife trafficking" OR "illegal wildlife" OR "fauna crime*" OR "forest crime*" OR "illegal logging" OR "illegal fishing" OR "fisheries crime*")) AND PUBYEAR > 2005 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "ch") OR LIMIT-TO (DOCTYPE, "bk") OR LIMIT-TO (DOCTYPE, "re") OR LIMIT-TO (DOCTYPE, "cp"))
WoS	("Money laundering" and ("Environmental crime*" or "plastic waste" or "waste dumping" or "illegal waste" or "wildlife trafficking" or "illegal wildlife" or "fauna crime*" or "forest crime*" or "illegal logging" or "illegal fishing" or "fisheries crime*")) AND ALL=("Money laundering" and ("Environmental crime*" or "plastic waste" or "waste dumping" or "illegal waste" or "wildlife trafficking" or "illegal wildlife" or "fauna crime*" or "forest crime*" or "illegal logging" or "illegal fishing" or "fisheries crime*"))

Note: In Scopus, "TITLE-ABS-KEY" is a search field abbreviation used to retrieve information based on the title, abstract, and keywords. The "*" symbol acts as a wildcard, broadening the search to include words that begin with the same letters. Searches were conducted under the "All fields" category.

From the existing literature, we found that research on money laundering related to environmental crimes remains underexplored, as evidenced by the limited number of studies available in major academic databases. Although there has been a recent surge in attention to money laundering from environmental crimes, the FATF is driving most of this emphasis, with a limited number of studies from the academic literature (Financial Action Task Force, 2020, 2021). Illegal activities such as logging, wildlife trafficking, fishing, and hazardous waste disposal are widely discussed in the literature, with many studies highlighting their link to corruption (Arminen & Menegaki, 2019; Gan et al., 2016; Lee & Viswanathan, 2020; Lupton, 2023) with indirect mentioned to money laundering.

Similarly, research on TBML from environmental crimes remains in its early stages, with few academic studies, many of which are indexed outside major databases like Scopus and WoS, including a book written by Smith (2023) or chapter in a book by Mohamed Yousop, Ab Razak, and Amin Noordin (2024b) Most of the existing literature comes from organizations like the FATF, OECD, and the United Nations Conference on Trade and Development (UNCTAD), which are not primarily academic. Ferwerda (2023) states that money laundering research is still evolving, emphasizing the need for more reliable and robust estimating approaches. Continued exploratory and empirical research is critical to improve our understanding of the complex challenges of money laundering in global trade.

3. REVIEWS ON LITERATURE

3.1. The Rise of Environmental Crimes and Trade in Southeast Asia

Environmental crimes refer to any illegal activities that harm or exploit the natural environment and its resources, including, but not limited to, forest crimes, illegal wildlife trade, illegal fishing, and illegal waste disposal (Financial Action Task Force, 2021). In international trade, environmental crime refers to illegal activities that harm the environment, cross national borders, and can significantly impact countries or regions (White, 2011). As shown in Table 2, the estimated value of environmental crime ranges from millions to billions annually, with forest crime accounting for the highest figures. Southeast Asia is particularly affected by forest crime, with its rich forests contributing to some of the highest rates of environmental crime globally. While other environmental crimes are also present across the broader Asian continent, evidence from the flora and fauna crime index, as discussed in the previous section, shows that Southeast Asia contributes more than other regions. The region's abundant environmental resources generate domestic and international demand, resulting in significant pressures and unique challenges.

Additionally, the porous borders of Southeast Asian countries facilitate the illegal movement of goods and people, establishing the region as a key hub for transnational environmental crime networks (Schaper, 2020).

Table 2. Categories of crime, estimated crime values, countries of origin or direction, and types of criminal activities.

Categories	Estimated crime values	Countries of origin	Types of criminal activities
Forestry crime	Between USD 51 billion and USD 152 billion annually	Central and South America, Central and Southern Africa, Southeast Asia, and parts of Eastern Europe	Illegal logging and illegal mining
Fisheries crime	Between USD 25.5 billion and USD 49.5 billion annually	Asia	Illegal fishing or crime related to fishing vessels, such as drugs and human trafficking
Wildlife crime	USD 630 million (Rhino horn and ivory trafficking)	Asia and Southern Africa	Elephant poaching, seizure, and illegal wildlife trade
Pollution or waste crime	USD 529.45 million (Estimation from 27 cases)	North America, Western Europe, Sub-Saharan Africa, Southeast Asia, and Central and South America	Illicit chemical trafficking and illicit hazardous waste trade

Note: Information was compiled from the international criminal police organization (INTERPOL) and united nations environment programme (UNEP) websites. The origin and direction of each crime type were adapted from Baker (2005) with additional information from the Financial Action Task Force (2021).

For decades, research in Southeast Asia has highlighted the severe consequences of illegal logging and wildlife trafficking, which have caused significant deforestation and pose a serious threat to endangered species. A study by Hoare (2015) identified Indonesia, Brazil, and Malaysia as major hubs for illegal timber. Indonesia alone accounted for nearly half of the global trade in illegal timber in 2013. Brazil and Malaysia contributed 25% and 10% respectively that same year. Further analysis of high-resolution satellite data from 2001 to 2019 shows that deforestation in Southeast Asia's biodiverse and carbon-rich tropical montane forests is accelerating, with an average of 3.22 million hectares of forest lost annually. Notably, 31% of this loss occurs in mountainous regions (Feng et al., 2021). These activities destroy critical wildlife habitats, increase carbon emissions, and intensify the region's contribution to global climate change, reversing decades of conservation progress (Noor et al., 2022). At the same time, the growing demand for commodities derived from endangered species, such as elephant ivory and rhinoceros horn, is driving multiple species toward extinction (Basel Institute on Governance, 2021). Criminal networks exploit Southeast Asia's complex maritime routes and inadequately regulated land borders to traffic timber and wildlife products, evading detection and further jeopardizing the region's biodiversity.

In Southeast Asia, the fragmentation among anti-corruption units, financial investigators, and environmental protection agencies severely undermines efforts to combat trafficking in timber and wildlife (Organisation for Economic Co-operation and Development, 2019). These bodies seldom share intelligence or coordinate operations, resulting in gaps that traffickers exploit by routing illicit consignments through special economic zones and under simplified customs regimes with minimal oversight. Corruption at border checkpoints further weakens controls, as low-level officials may accept bribes to ignore falsified documentation. Moreover, financial intelligence units rarely designate proceeds from wildlife trafficking as criminal assets under national legislation, so that syndicates can launder funds through correspondent banking arrangements without rigorous scrutiny (Financial Action Task Force & Egmont Group, 2020b). This combination of institutional division, legal lacunae, and corruption enables large-scale trafficking with impunity and poses a serious obstacle to regional environmental governance.

Southeast Asia has recently grappled with illegal processing of electronic waste (e-waste), as the region has become a prime destination for global e-waste flows (United Nations Office on Drugs and Crime, 2022). Illegal e-waste facilities, often outside regulatory oversight, discharge harmful pollutants into rural environments, posing

significant health risks to surrounding communities (Baldé, Angelo, Luda, Deubzer, & Kuehr, 2022). China's 2018 ban on plastic waste imports shifted the burden of global waste to Southeast Asia, particularly Malaysia, Vietnam, Thailand, and Indonesia, further straining an already fragile regulatory system. While some policies have been implemented to address illegal imports and improve waste management standards, enforcement remains insufficient, given the scale of trafficking. These ongoing and complex challenges emphasize the urgent need for cohesive, ASEAN-led policies to strengthen oversight and enforcement, protecting the region's environmental resources and public health from the rising threat of transnational environmental crime (Bueta, Nicole, Torres, Kamaruddin, & Cornelius, 2021; United Nations Office on Drugs and Crime, 2022).

In light of the above issues, one critical yet often overlooked aspect of environmental crime in the region is the financial trail of criminal proceeds. As seen in Table 1, these illegal activities generate enormous revenues ranging from millions to billions of dollars, making traditional banking channels too risky for criminals. Additionally, Yamaguchi (2023) stated that environmental crimes frequently involve the illicit trade of environmentally sensitive commodities, such as wildlife and timber. This trade is fueled by criminals' efforts to evade environmental regulations, which also facilitates TBML by manipulating import and export invoices. In 2021, illicit cross-border money transfers were estimated to account for about 20% of the total trade value between these economies, highlighting their significant involvement in this hidden economy (Global Financial Integrity, 2023). As a result, widespread money laundering in the financial system poses major concerns, such as destabilizing financial institutions, impeding economic development, and jeopardizing the integrity of international commerce.

3.2. From Trade Mis-invoicing to TBML: What Drives the Shift?

Trade mis-invoicing emerges as a dominant method in TBML, representing nearly two-thirds of documented cases according to recent analyses by the GFI. When examining trade patterns between developing nations and their trading partners over the 2009-2018 period, the GFI uncovered significant value discrepancies, with Chinese and Indian trade flows showing concerning gaps. The Southeast Asian region also stands out, with Malaysia, Thailand, and Indonesia ranking among the countries exhibiting the most substantial value mismatches in international trade (Global Financial Integrity, 2020, 2021). These patterns reveal how malicious actors exploit trade documentation to disguise the true worth and source of goods, effectively laundering illicit funds through legitimate trade channels (Huu Toan, 2022; Tiwari, Ferrill, & Allan, 2025).

At its core, trade mis-invoicing manipulates the declared values of cross-border transactions through deliberate under- or over-invoicing, facilitating unauthorized fund transfers across borders (McSkimming, 2010; Soudijn, 2014; Tiwari et al., 2025; Zdanowicz, 2017). Past trade data also indicates that under-invoicing occurs more frequently in over half of suspicious transactions. However, over-invoicing cases involve larger sums—roughly USD 3.1 million compared to USD 2.3 million for under-invoicing instances (Mavrellis, 2021b).

Recent investigations reveal how trade mis-invoicing increasingly facilitates environmental crimes by masking the true nature and value of environmental resources (Financial Action Task Force, 2021). This practice enables criminals to integrate illegal environmental proceeds into legitimate trade flows through falsified documentation. For example, some criminals have manipulated shipping records to conceal illegal rosewood shipments by labelling them as harmless commodities such as pangolin scales or tea leaves. This fact is supported by Nellemann et al. (2016) research, which states that the Asian pangolin species has suffered considerably due to trade activities. Enormous amounts have been trafficked from Southeast Asian countries to China as a result of this illegal trade practice. An intriguing study conducted in Colombia also provides support for this issue. According to Mavrellis (2021a), an examination of trade between 2009 and 2018 revealed that trade mis-invoicing contributes to money laundering from environmental crimes. Their investigation also uncovered approximately USD 5.4 million in erroneously billed shipments from 1,067 problematic arrangements involving the export of tropical wood products. These figures are concerning because they reflect a portion of Colombia's wood exports and total export transactions, demonstrating

how incorrect trade mis-invoicing can conceal the unlawful trafficking of valuable environmental resources.

Concurrently, as stated in the previous section, previous research has found a link between corruption and environmental crimes, which can lead to money laundering activities (Barone & Masciandaro, 2023; Yamaguchi, 2023). Corruption contributes to resource exploitation by undermining regulatory institutions and enforcement mechanisms, allowing illicit operations such as unauthorized deforestation, wildlife smuggling, and improper waste disposal methods. The situation is evident in Southeast Asia, where political and economic instability and widespread corruption impede efficient governance and responses to environmental crimes (Farrelly, Dawkins, & Deegan, 2022; Schoeberlein, 2020; United Nations Office on Drugs and Crime, 2024). Such situations, such as illegal logging in Indonesia (Smith, Obidzinski, Subarudi, & Suramenggala, 2003) and forest-related corruption in Malaysia (Noor et al., 2022), show how these challenges present differently across locations, suggesting more focused and context-sensitive solutions. Criminals frequently collaborate with corrupt officials to legitimize, conceal, and transport illegally obtained assets (Mavrellis, 2021a; Shelley, Nancy, & Omar, 2020). Furthermore, the exploitation of these resources by governmental and commercial actors creates an enabling climate for money laundering, which fuels poor governance institutions and enormous financial rewards. This cooperation allows these acts to go unnoticed, undermining legal and regulatory systems and eroding public trust in government institutions (Cerutti, Tacconi, Lescuyer, & Nasi, 2012; Conway & Hermann, 2021).

As a result, the mitigation of TBML requires an extensive approach beyond typical AML measures. While perfect prevention remains unlikely due to evolving criminal tactics, effective reduction of cases related to this issue appears feasible, depending on coordinated efforts between financial institutions, law enforcement, and key stakeholders to lessen its impact on the global financial system (Wang, 2021). Timely reporting of suspected transactions to customs authorities, along with aggressive enforcement measures, including high penalties, has been beneficial in preventing illegal financial flows (Batayneh et al., 2022). Furthermore, developments in financial services have created new opportunities to prevent TBML. Recent research shows that financial technology (FinTech) innovations, especially blockchain, artificial intelligence, and machine learning algorithms, have reshaped the AML regulatory framework (Liu, Choi, & Kim, 2024; Nur Liyana Mohamed Yousop, Ab Razak, & Noordin, 2024a). Incorporating these technologies into AML frameworks advances the global fight against money laundering by providing innovative solutions previously unavailable through traditional methods (Kurum, 2023; Pocher, Zichichi, Merizzi, Shafiq, & Ferretti, 2023). Moreover, these innovations can also improve transparency and accountability in environmental accounting by generating immutable transaction records and enabling automated environmental data monitoring (Sholehah, Ishak, & Utiarahman, 2024).

4. EMPIRICAL EVIDENCE

Since we found that TBML research in Southeast Asia remains limited in the existing literature, we decided to investigate further the association between TBML and environmental crime incidents across Southeast Asia. Southeast Asia represents one of the most effective economic blocs with significant trade activity, making it crucial to understand these criminal dynamics. First, we draw upon two fundamental theories: the economics of crime and the resource curse theory. Through the cost-benefit framework, the economics of crime posits that individuals engaged in criminal activities, like money laundering, assess the potential financial benefits against the risks of being apprehended (Becker, 1968; Ferwerda, 2018). If the perceived benefits outweigh these risks (i.e., costs), criminals may feel incentivized to proceed with illegal activities.

On the other hand, resource curse theory posits that countries rich in natural resources often encounter economic and governance issues, including corruption and weak institutions (Auty, 1993; Tsogtochir & Park, 2021). These challenges can create an environment where illicit activities such as TBML thrive. As the trade in natural resources increases, so do the opportunities and motivations for money laundering. Second, we analyze trade mis-invoicing data sourced from the GFI as a proxy for TBML from 2012 to 2018. This timeframe was chosen because the GFI only

provides data for the past ten years, from 2009 to 2018, and subsequent data is unavailable. As independent variables, we also gathered data on illegal trade incidents involving flora and fauna from the Environmental Investigation Agency (EIA). Each incident has been carefully compiled and categorized according to the type of crime involved. Since most of the EIA data is complete from 2012 onwards, the time frame for the study was set from 2012 to 2018 to ensure a balanced panel dataset.

Table 3 presents the summary statistics between TBML and environmental crime trade incidents. We observe a relatively homogeneous group of dependent and control variables, as evidenced by their standard deviations being below their respective means.

In contrast, independent variables show greater dispersion, with standard deviations exceeding those of the control and dependent variables. This greater dispersion reflects heterogeneity in the occurrence of environmental crime incidents across the sample, possibly due to varying enforcement capacities or differing levels of environmental crime across countries.

The multicollinearity test confirms that multicollinearity is not an issue for the model. Variance Inflation Factor (VIF) values for lnCOR and lnGOV are 4.74 and 4.46, respectively, while WLC, FOC, and lnMOV have values below 2. These results suggest that the predictors are not highly correlated, ensuring reliable and robust estimates.

Table 3. Summary statistics.

Variable	Obs	Mean	Std. dev.	Min	Max	Skew	Kurt
lnTBML	56	23.374	1.559	19.887	24.991	-0.665	1.987
WLC	56	13.732	16.487	0.000	70.000	1.473	4.635
FOC	56	11.661	16.022	0.000	76.000	1.991	7.025
lnCOR	56	3.442	0.281	2.708	3.951	-0.329	2.666
lnGOV	56	3.362	0.347	2.454	4.004	-0.369	2.866
lnMOV	56	1.920	0.218	1.419	2.239	-0.757	2.456

Note: ln is the natural logarithm. TBML refers to trade misinvoicing, which serves as a proxy. Independent variables are WLC (Wildlife trade incidents) and FOC (Forest trade incidents, specifically illegal logging incidents). Control variables include COR (Corruption levels from Transparency International's Corruption Perceptions index), GOV (Government intervention), and MOV (Freedom of movement), both extracted from the Fraser Institute. Due to data constraints, not all Southeast Asian countries, such as Singapore, Brunei Darussalam, and Timor-Leste, are included in the analysis.

The estimation results from Pooled Least Squares (POLS), Random Effect Model (REM), and Fixed Effect Model (FEM) are presented in Table 4. The analysis begins with models [1] to [3], which do not include any time-specific factors that might affect all individuals simultaneously (one-way model). In these models, it was found that FEM is preferable, as Poolability, Hausman, and Sargan-Hansen tests show significant results.

Consequently, individual and time-specific fixed effects (i.e., year dummies) were included. Including year dummies controls for factors that are constant across individuals but vary over time, such as global economic events or changes in government policies. Results from the two-way FEM indicated that the inclusion of the time effect was not statistically significant.

These findings suggest that the year dummy variable does not contribute additional explanatory power in this context. As a result, the decision was made to retain the third model, which does not include the time-specific effects. However, diagnostic tests revealed that the FEM did not pass the heteroscedasticity test and only marginally passed the serial correlation test at the 1% significance level.

Table 4. Estimation results of one-way POLS, REM and FEM and two-way FEM.

DV: *ln*TBML	One-Way			Two-Way
	[1] **POLS** **(S.E)**	**[2]** **REM** **(S.E)**	**[3]** **FEM** **(S.E)**	**[4]** **FEM** **(S.E)**
WLC	0.032***	0.018**	0.015**	0.011
	(0.008)	(0.007)	(0.007)	(0.008)
FOC	0.004	0.005	0.005	0.003
	(0.008)	(0.003)	(0.003)	(0.003)
*ln*COR	3.702***	1.876***	1.693***	1.202**
	(0.813)	(0.450)	(0.437)	(0.469)
*ln*GOV	–0.348	–0.046	–0.060	–0.171
	(0.637)	(0.251)	(0.237)	(0.282)
*ln*MOV	1.772***	–0.328	–0.918	–0.156
	(0.548)	(0.674)	(0.698)	(0.745)
Constant	7.918***	17.400***	19.250***	19.660***
	(1.444)	(1.654)	(1.654)	(1.697)
Observations	56	56	56	56
R^2 (Overall)	0.774	0.670	0.526	0.599
R^2 (Within)		0.421	0.434	0.548
F-test	34.320***		6.58***	4.070***
Wald chi$_2$-test		39.500***		
Year dummy	No	No	No	Yes
F-stat (Year dummies)				1.550
Poolability F-test			51.060***	54.590***
Breusch-Pagan LM test		86.380***		
Hausman test			10.240*	10.710*
Sargan-Hansen test			11.588**	12.553**
Diagnostic tests				
H-test p-value	0.000	0.240	0.000	0.000
CSD test p-value	0.848	0.320	0.585	0.129
SC-test p-value	0.000	0.071	0.044	0.015

Note: DV is a dependent variable. S.E is the standard error in parentheses. The H-test is a heteroscedasticity test, the CSD test is a cross-section dependence test, and the SC-test is a serial correlation test. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

In order to address the issue of heteroscedasticity and serial correlation, we used robust standard errors, as in Table 5. This adjustment ensures more reliable statistical inference, enhancing the robustness of the model's estimates despite the diagnostic challenges observed in the initial analysis. Our findings show a significant relationship between illegal wildlife and forest trade incidents with TBML. Although the significance is only at the 10% level, the results indicate a positive association with TBML. Specifically, after controlling for corruption, government intervention, and freedom of movement in Southeast Asia, each additional case of illegal wildlife trade incidents is associated with a 0.15% increase in TBML. In comparison, each additional case of illegal forest trade incidents is associated with a 0.05% increase in TBML.

Table 5. Estimation results of one-way FEM (Robust standard error).

DV: *ln*TBML	One-way FEM (Robust S.E)
WLC	0.015*
	(0.01)
FOC	0.005*
	(0.002)
*ln*COR	1.693***
	(0.247)
*ln*GOV	-0.060
	(0.149)
*ln*MOV	-0.918**
	(0.373)
Constant	19.250***
	(1.420)
Observations	56
R-squared (Overall)	0.526
R-squared (Within)	0.434
F-test	19.850***
Year dummy	No

Note: DV is a dependent variable. Robust S.E is a robust standard error in parentheses. *** p<0.01, ** p<0.05, * p<0.1.H-test is a heteroscedasticity test.

5. CONCLUDING REMARKS

Studies on money laundering have long existed. Nevertheless, the rapid escalation of TBML from environmental crimes brings renewed significance to this field of study. Our primary objective is to explore the existence of TBML in environmental crimes through a review of past literature. The investigation begins with a broad exploration of the phenomenon, followed by a narrowing of focus to the Southeast Asia region. The findings show that research on TBML from environmental crimes remains limited both globally and within the Southeast Asian region. A key limitation of this investigation is that most sources are not drawn from well-known academic databases but are primarily based on agency reports, university theses, book chapters, and working papers. This can also be attributed to several factors, including data constraints (Cobham & Janský, 2020; Tiwari et al., 2025) and a lack of exploration in grey economy studies (Ferwerda, 2023). Motivated by these concerns, we scrutinize empirical evidence on TBML and its connection with environmental crime incidents. Although the TBML measurements are drawn from trade mis-invoicing data, environmental crimes significantly positively affect TBML. This demonstrates that trade constitutes a critical conduit for laundering beyond conventional channels, owing to the complexity and interconnectedness of global commerce. The results imply that criminal organizations adapt by exploiting trade structures to disguise illicit funds. Our findings also reveal a significant influence of corruption and freedom of movement. Although these factors were not directly analyzed as independent variables, they indicate that corruption remains a significant concern in money laundering studies. On the other hand, freedom of movement relates to TBML by facilitating the unrestricted flow of goods, services, and people across borders. Criminals can exploit open borders and minimal restrictions to conceal illegal financial flows within legitimate trade transactions. However, we also acknowledge that our conclusions have certain limitations. The measurement of trade mis-invoicing relies on the coverage and accuracy of officially reported mis-invoicing and crime statistics, which are likely to understate the true extent of laundering activities. Future studies could address these limitations by utilizing transaction-level datasets and expanding the scope of environmental crime variables included in the analysis.

Finally, we conclude that policymakers must implement a comprehensive strategy addressing all dimensions of TBML. It is essential to perform an in-depth evaluation of regulatory frameworks in Southeast Asia to identify gaps exploited by criminal networks and to address barriers hindering effective cross-border cooperation. Integrating real-time artificial intelligence fraud detection systems with rigorous security protocols would significantly enhance transaction transparency and act as a deterrent (Liu et al., 2024). Nonetheless, excessively stringent enforcement

through rigorous customs procedures and punitive measures may push laundering activities underground (Pellegrina, Di Maio, Masciandaro, & Saraceno, 2023). Therefore, a balanced policy approach combining vigilant regulatory oversight with measures facilitating legitimate trade is crucial to reduce the economic incentives driving TBML associated with environmental crime.

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