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Effect of Trade Restrictive Provisions with Due-Diligence on Bilateral Trade Flows: The Case of the US Regulation on Conflict Minerals^{*}

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Abstract

The US Congress passed the Dodd--Frank Wall Street Reform and Consumer Protection Act in 2010. It includes the provision (section 1502) of a due diligence requirement: publicly listed firms in the US Securities and Exchange Commission must check their supply chains for tantalum, tin, tungsten, and gold originating from the Democratic Republic of Congo (DRC) or neighboring countries thereof and must check if they are free from conflicts in the target region. Focusing on tantalum and tungsten, this study empirically examines (i) the effect of the act on trade flows from the target countries to the US, and (ii) the trade diversion effects in terms of both production (export) and consumption (import) sides. We also clarify whether the act weakens the relationship between international transactions and conflicts, by using the data provided by the Department of Peace and Conflict Research, Uppsala University, on the number of georeferenced deaths caused by such conflicts. We find that the export from the target countries to the US and OECD countries decreased after the act was enforced, whereas the trade diversion effects rose. Although the act weakened the relationship between trade values and conflicts, there is a possibility that corruption in the trade of these resources increased.

Keywords: Conflict minerals, the Dodd-Frank Act, gravity approach, process and production methods

(PPMs), trade restrictive measures.

JEL classification: F14, F18, Q34, Q37.

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1 Introduction

The ethics of global economic activities have become a common concern among a wide range of stakeholders, including everyday citizens. For example, many consumers consider themselves responsible for the protection of the environment and human rights during the production processes of the products they purchase. In fact, consumers readily reflect their perceptions thereof in their consumption behavior through standardized labels, including eco-labels and fair-trade marks. Such consumers believe that firms should bear the corresponding responsibility for both themselves and their supply chains. In response, firms have also been making effort to fulfill their social corporate responsibility (CSR), and due diligence now often covers ethical issues for the whole supply chain.¹

In tandem with the behavioral changes in consumers and producers, governments sometimes proactively approach these issues as well. In some cases, they seek to solve domestic issues, but may intervene in ethical issues outside their jurisdiction. A famous example is the import ban against Mexican tuna products, on the grounds of environmental and resource concerns, enforced by the US government at the beginning of the 1990s, which is well known as the *tuna-dolphin case*. That is, the US government intervened in a process and production method (PPM) outside its jurisdiction as a move to protect dolphins that were being harmed during tuna fishing activities on the Mexican coast.²

In a globalized economy, supply chains easily cross national borders, and multilateral supply chains are not uncommon. This has made it likelier that a government's actions toward a firm's environmental, resource, and human rights due diligence can influence economic activities outside its jurisdiction through international trade networks; this has been the trend for the past few decades now. One such provision is section 1502 of the Dodd–Frank Wall Street Reform and Consumer Protection Act (from hereon, the Dodd–Frank Act), which passed the US Congress in 2010.³ This provision prescribes due diligence requirements on the use of four kinds of resources (tantalum, tin, tungsten, and gold, collectively known as 3TG) relating to conflicts in the Democratic Republic of Congo (DRC) and its neighboring countries.⁴

¹In this paper, we specifically deal with *due diligence* in the mineral supply chain, which the Organisation for Economic Co-operation and Development [OECD] (2016, p. 13) defines as "an on-going, proactive and reactive process through which companies can ensure that they respect human rights and do not contribute to conflict."

 $^{^2 \}mathrm{See}$ Beyers (1992) for the process of the tuna-dolphin dispute.

 $^{^{3}}$ The Dodd–Frank Act is a comprehensive law to regulate financial transactions, and the provision relating to conflict minerals is a small part of this act. However, we refer to the Dodd–Frank Act in this paper to denote section 1502 thereof.

⁴As explained in subsection 3.2, the SEC published the finalized rule of disclosure and reporting in mid-2012. For the details of the process of the enforcement of the Dodd–Frank Act, see Taylor (2012) and Woody (2012).

The central African area, including the DRC and its neighboring countries, is richly endowed with mineral resources, including 3TG. These resources could bring about economic development and affluent living for ordinary citizens in this area if the industry and production activities were well managed. However, the DRC has long remained in the grips of serious conflicts and violence, and a part of the revenue from resource extraction has become a source of the execution of those conflicts. Juveniles, for example, are often forced to take up arms, and workers at extraction sites are subject to violations of their rights. Thus, the Dodd–Frank Act aims at impeding the transaction of conflict resources and instead encouraging the supply of conflict-free resources.⁵

There are three important institutional features of the Dodd–Frank Act in terms of its effects on trade flows. First, the publicly listed firms in the SEC, which are directly required to comply with the due diligence requirement under Provision 1502, must bear the cost of the certification for the sources of resources they use. Firms that supply resources and materials to the listed firms, which we refer to as suppliers, may also be required to comply with the provision if they want to remain included in the supply chains. This implies that, compared with the absence of the act, it is costly for all firms in the supply chains to serve their products to the US market. In other words, firms that fulfill the due diligence requirement may bear the responsibility for the protection of human rights and the dissolution of the link with conflicts through their whole supply chains.⁶

In particular, the cost may be large when firms transact 3TG with suppliers in the target countries. For example, the SEC's policy cost estimation of adhering to due diligence was USD 3–4 billion only for the first year, although the realized costs may be smaller than the estimated ones.⁷ This increase in cost could significantly affect trade flows. In fact, Jeffrey's (2012) survey of the situation in the DRC after the Dodd–Frank Act was enforced showed that the act served as a de facto embargo. Moreover, natural resources are unevenly distributed across a small number of countries, and firms in a variety of downstream sectors in the manufacturing industry procure resources and materials through international trade. Thus, the Dodd–Frank Act has significant effects not only on the trade flows between the US and the target countries but also on the global trade networks of these resources.

Second, as noted above, this scheme intervenes with economic activities outside the jurisdic-

 $^{{}^{5}}$ The Dodd–Frank Act uses *minerals* to express the target resources. However, we also use *resources* interchangeably.

⁶This cost is expected to be very high if a publicly listed firm fulfils the whole process for satisfying the requirements by itself. Thus, firms usually use the information provided by third-party certification bodies. For example, Responsible Minerals Initiative provides the list of smelters and refiners that satisfy the conditions of the requirements. See https://www.responsiblemineralsinitiative.org/smelters-refiners-lists/.

⁷See Schwartz and Nelson (2016) for the detailed analysis of the estimations and actual costs.

tion of the US. In other words, it may fall into the category of an intervention into PPMs existing in a foreign country. Unless the trade restriction falls into the category of exceptions stipulated in Article XX of the General Agreement on Tariffs and Trade, member countries of the World Trade Organization are not allowed to enforce trade restrictions. Although the provision of the Dodd–Frank Act is not a direct trade restriction, it is neither a pure private standard nor a pure action by private organizations such as NGOs.⁸

Third, the provision is applied to specific countries in a discriminatory manner. Thus, the trade-restrictive provision generates *losses from trade* to the target resource-exporting countries, which implies that a type of *negative* regional trade agreement (RTA) is created. Trade volumes in both directions increase between any two member countries in the case of general RTAs. However, in the case of the due diligence requirement in the Dodd–Frank Act, the trade quantities from the target countries of the act to the US decrease; that is, the act generates one-way negative effects. Similar to RTAs, this trade-restrictive scheme may generate *trade diversion* on both the production and consumption sides. A trade diversion in terms of the production side arises when the export volumes from the target countries to the third countries may increase instead of a decrease in the export to the US from the producing countries other than the target countries increase instead of a decrease in the import sfrom the target countries.

Considering these characteristics, it is important to clarify the economic effect of the Dodd– Frank Act so that policymakers may design efficient and fair regulation schemes. This study empirically sheds light on the trade-restrictive effect of the Dodd–Frank Act on bilateral trade flows using the structural gravity approach. As noted above, given that trade volumes from the target countries to the US are expected to reduce, and that a trade diversion effect may arise, we need to distinguish the directions of trade between countries. Although many studies have investigated the trade creation and diversion effects of RTAs, relatively few studies have conducted rigorous empirical analyses on the effect of PPM-related trade measures.⁹ We also aim to capture whether the Dodd–Frank Act has generated *detour trade*. For example, although the bilateral flows from the target countries to the US may decrease, resources may be exported indirectly from the target countries to the US via third countries. Thus, the trade flows from the possible third countries to the US need to be examined.¹⁰

⁸Although there is no complete consensus at the moment, it is considered that Article XX (a) and/or (b) may be applied to justify this trade-restrictive scheme.

⁹See Magee (2008), Zidi and Dhifallah (2013), Dai et al. (2014), Urata and Okabe (2014), Jagdambe and Kannan (2020), and Pfaffermayr (2020) for empirical studies on the trade diversion effect of RTAs.

¹⁰In this study, we designate such trade flows from the possible third countries to the US (or OECD countries)

Several studies have investigated the effect of the Dodd–Frank Act on firms' behavior and performance. For example, Seitz (2015) investigated the effect of this act on the stock prices that were traded on the major US exchanges, Via and Perego (2018) examined the firms' incentives to file conflict minerals disclosure, and Swift et al. (2019) shed light on the effect of disclosure on firms' performance such as profitability and sales. The effect of the Dodd–Frank Act on the DRC society has also been examined. For example, Parker et al. (2016) investigated its effect on infant mortality rate and found that the act decreases the household revenue in the region of resource extraction in the DRC, leading to a decrease in parents' expenditure on child health care and an increase in infant mortality rate. Parker and Vadheim (2017) demonstrated that the act increased battles and looting in the DRC through decreases in resource prices. Stoop et al. (2018) also examined the effect of the act by using the data covering longer periods than Parker and Vadheim (2017) used, and still reached a similar conclusion.¹¹

When it comes to the effect of the Dodd–Frank Act on international trade of target resources and regions, Schütte (2019) examined the trade flows of tantalum and tin ores and concentrates from the Great Lakes region in Central Africa to smelter countries. He found that the act worked as a de facto embargo for the first few years in the transition period before full enforcement (from 2010 to 2012), but the exporting volumes from this region increased and returned to the preenforcement period by 2014. He pointed out that the changes in the market and supply chains structures after 2010 led to an increase in exporting volumes of resources from the African Great Lakes region.¹²chütte and Näher (2020) focused on tantalum production in the Great Lakes region, and elucidated the extraction and exporting structure in this area.

This study is also related to the literature on the empirical analysis of the trade effects of indiscriminate regulations, private standards, or border adjustment. For example, Xiong and Beghin (2014) investigated the effect of maximum residue level regulations (indiscriminate regulations) and Ehrich and Mangelsdorf (2018) examined the effect of certification of the International Featured Standards (private standards). Both their studies confirm that these regulations and certification systems may become trade barriers for exporters in the least developed countries. The common feature of our study with their analyses is the estimation of the effect of trade-related regulations increasing the cost of trade through the act's influence on PPMs in the

as $detour\ trade.$

¹¹Several other studies have focused on the conflicts in the DRC or other African countries. However, they neglected to evaluate the effect of the Dodd–Frank Act. For example, Berman et al. (2017) used data on the conflicts and production activities pertaining to 14 resources in African countries from 1997 to 2010 and found that price increases were a causal factor in conflicts. Kelly's (2014) survey showed that conflicts made it difficult for farmers to earn their living from agriculture, and forced them to become artisanal miners.

 $^{^{12}\}mathrm{S}$

exporting countries. However, different from their analyses, we focus on the compulsory requirements for importers that increase the importing cost from the target countries in a discriminate manner.

Extending Schütte (2019), we investigate the effect of the Dodd–Frank Act on bilateral trade flows comprehensively. We include not only ores and concentrates, registered in Chapter 26 of Harmonized System (HS) codes, but also bars, rods, articles, and wire, registered in Chapter 81. The latter is the one-step downstream sector of the material flow of resources. However, they are often categorized as materials than products. Thus, in terms of the whole material flow (life cycle) of resources, items registered in both Chapters 26 and 81 are considered as those of upstream sectors. Hereafter, we refer to items in Chapter 26 and 80 as raw materials and intermediates, respectively. Because we aim at capturing the effect on global trade flows including trade diversion and detour trade, it is important to include the trade flows of downstream sectors into the empirical analysis. It may be necessary to include all kinds of manufactured products that use resources to capture the entire trade flows through their life cycles. However, the target resources in this study are used for producing a variety of products. Moreover, other kinds of resources are used for manufacturing those products. Thus, it is difficult to include manufactured products into our analysis without generating serious biases and, accordingly, we focus on the items in the two chapters noted above.

One important issue specific to trade in conflict resources is noteworthy. As pointed out by Schütte (2019), there were problems regarding the registration and reporting systems of exports in the target countries of the Dodd–Frank Act. Smuggling is an important problem when governments aim to eradicate transactions of conflict resources because smuggling reduces the effectiveness of a variety of governments' regulations and attempts by private organizations.¹³ The existence of smuggling makes it tricky to empirically estimate the effects of trade-restrictive schemes. Nevertheless, we consider that this study contributes to the extant literature in the following aspects. First, a set of fixed effects under a structural gravity approach makes it possible to avoid the problem presented by smuggling to some extent. For example, the effect of the flaws of monitoring systems of customs specific to each country can be removed by using exporter-year and importer-year fixed effects. Even if there exists a smuggling route between a certain pair of countries,¹⁴ if the specification of the route, such as the scale of smuggling organization, does not change during the period covered by the data, the effect of the smuggling

 $^{^{13}}$ The smuggling of resources in the central African region has also been investigated by Bleischwitz et al. (2012), Geenen (2012), and Mancheri et al. (2018).

¹⁴Schütte (2019) mentions that Rwanda, one of neighboring countries of the DRC, is a major hub for smuggling activities.

route can be removed by using pair fixed effects. Then, we can investigate the effect of the Dodd– Frank Act on legal trade and production networks in terms of the cost increase for meeting the due diligence requirements.

Second, however, it is difficult for a set of fixed effects to remove the effects of smuggling completely. Then, combined with the findings of the existing case and empirical studies on smuggling and mining activities (e.g., Bleischwitz et al., 2012; Geenen, 2012; Kelly, 2014; Mancheri et al., 2018; Schütte, 2019, 2020), our analysis reveals the factors that should be carefully considered when tackling the smuggling problem, such as the substitution effect and countries with small trading scales.

Third, this study also examines if the act has successfully weakened the relationship between resource extraction and conflicts in the DRC and neighboring countries by using conflict data. Although studies have clarified this relationship by focusing on specific countries, we extract the essential effect of the act by removing the effect of other factors specific to each country and pair.

The remainder of the paper is structured as follows. Section 2 describes the theoretical background. Section 3 mentions the empirical specification such as the data and empirical methods. Section 4 explains the estimation results including the relationship between trade and conflicts. Section 5 concludes.

2 Theoretical Background

The theoretical background for our empirical analysis can be constructed based on Xiong and Beghin (2014), that is, goods are differentiated depending on both country of origins for producers and country of destinations for consumers. Although we use a panel data in the empirical estimations, we abbreviate the index for periods in the theoretical setup.

The utility maximization problem for a representative consumer in country $j(u_j)$ is given by

$$max_{q_{kij}}u_j = \left[\sum_k \sum_i (a_{ij}q_{kij})^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}},$$

$$s.t.\sum_k \sum_j p_{kij}q_{kij} = E_j,$$
(1)

where i, j, and k are the indices for exporting countries, importing countries, and goods, respectively. q_{kij} and p_{kij} are the quantity and price demanded for good k produced in country i and consumed in country j, respectively. Moreover, E_j and σ denote the expenditure for all differentiated goods by the representative consumer in country j and constant elasticity of substitution, which is greater than one ($\sigma > 1$), respectively. Finally, a_{ij} represents the subjective evaluation of the representative consumer in country j about goods produced in country i. Specifically, the definition of subjective evaluation is defined as follows:

$$a_{ij} = exp(\alpha_{ij} Dodd_{ij}). \tag{2}$$

We have three specific features for the subjective evaluation. First, $Dodd_{ij}$ takes zero before the Dodd–Frank Act is enforced, and then takes a specific positive value after the act is enforced for each pair of countries.¹⁵

Second, different from Xiong and Beghin (2014), wherein the evaluation depends on the regulation in the importing country j, the subjective evaluation in the present setting depends on both the situation in the exporting and importing countries. Basically, consumers in the US consider that the risk of purchasing resources that contain conflict ones actualizes when the Dodd–Frank Act is enforced. If the consumer is a final goods producer using those resources, the consumer may be afraid of receiving a negative evaluation in the market when the use of conflict resources is revealed even if the use is unintentional. Thus, α_{ij} is clearly negative when i is the DRC or a neighboring country and j is the US. Consumers in the other countries may also change their perceptions about the risk because they may become aware of conflict resources by observing the enforcement of the act or they may have business transactions with firms in the US. α_{ij} is negative in such cases when i is the DRC or a neighboring country.

Third, the consumers' perception is formed and risk evaluation is conducted based on the exporting country. Thus, even when we consider several kinds of raw materials and intermediates, it is assumed that a_{ij} does not depend on k.

The utility maximization yields the following import demand (v_{kij}) :

$$v_{kij} = p_{kij}q_{kij} = \frac{a_{ij}^{\sigma-1}p_{kij}^{1-\sigma}}{\Psi_j E_j},$$
(3)

where $\Psi_j (= \sum_k \sum_i a_{ij}^{\sigma-1} p_{kij}^{1-\sigma})$ denotes the consumer price index in country *i*.

Goods are also differentiated in terms of producers depending on destinations.¹⁶ The profit maximization problem for a representative producer of good k in country i is given by

$$max_{Q_{k,ij}} \sum_{j} P_{kij} Q_{kij} \tag{4}$$

¹⁵This variable is time-varying. In the empirical part, we adopt two types of positive values that corresponding to $Dodd_{ij}$ in the theoretical part: One is the dummy variable and the other is the number of victims caused by conflicts in the DRC or each of the DRC and its neighboring countries.

¹⁶Ores, concentrates, bars, and rods may be smelted and refined differently depending on the destination.

s.t.
$$\left[\sum_{j} (Q_{kij})^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} = C_{ki}$$

where Q_{kij} and P_{kij} are the quantity and price supplied of good k produced in country i and consumed in country j, respectively. Moreover, C_{ki} and θ are the production capacity of good k in country i and constant elasticity of substitution, which is less than zero ($\theta < 0$), respectively.

The relationship between the producer price in country $i(P_{kij})$ and the consumer price in country $j(p_{kij})$ is defined as

$$P_{k,ij} = \frac{p_{kij}}{\tau_{kj} t_{ij}},\tag{5}$$

where τ_{kj} denotes the ad valorem tariff (1+ tariff rate). In this study, we do not consider discriminatory tariff and, thus, the tariff rate does not depend on the exporting country (*i*). Moreover, t_{ij} is the trade cost term that includes trade costs when goods are exported from country *i* to country *j* other than custom duty payments, which is given by

$$t_{ij} = dist_{ij}^{\delta} \cdot exp\left(\sum_{l} \beta_{l} z_{l,ij} + \gamma_{0} r t a_{ij} + \gamma_{ij} Dodd_{ij}\right),\tag{6}$$

Assuming that the variable production cost is constant and the fixed cost is sunk, we do not explicitly describe the cost other than trade-related costs. *dist* denotes the distance between the two countries; z_l is a time-invariant pair variable, such as common border and common language; and *rta* is a dummy variable that takes 1 when both exporting and importing countries belongs to the same RTA and 0 otherwise.

Moreover, γ_{ij} represents the effect of country-pair specific trade costs regarding the effect of the Dodd–Frank Act. For example, the consumers in the importing country and the producer in the exporting country must bear the due diligence cost to comply with the conflict mineral provision of the Dodd–Frank Act. In such a case, γ_{ij} is considered positive. However, the size of the due diligence cost vary across importing countries even if the exporting country is the DRC or a neighboring country because the degrees of the relationship with the US consumers and producers are different depending on the importing country.

Contrarily, there are factors that make the sign of γ_{ij} negative. For example, when the risk of importing raw materials and intermediates from the DRC and neighboring countries becomes higher after the Dodd–Frank Act is enforced, the consumers in the importing countries may build a distribution network with resource-producing countries other than the target countries of the act. The development of new distribution networks may reduce the trade costs. Thus, when *i* is one of the other producing countries that are not target countries of the act, γ_{ij} can be negative after the Dodd–Frank Act is enforced. Some importing countries have many consumers who have weak relationship between the US. In such a case, those consumers may not care if their purchasing raw materials and intermediates are conflict-free or not. Then, they may build a new distribution network with the DRC and neighboring countries, which also leads to a negative value of γ_{ij} if *i* is the target country of the act. The possibility of negative value of γ_{ij} is important when considering the trade diversion and detour trade.

The profit maximization yields the following export supply (V_{kij}) :

$$V_{k,ij} = P_{kij}Q_{kij} = \frac{C_{ki}\tau_{kj}^{\theta}t_{kij}}{\Pi_{ki}p_{kij}^{\theta-1}},$$
(7)

where $\Pi_{ki} = \left[\sum_{j} \tau_{kj}^{\theta-1} t_{kij}^{\theta-1} p_{kij}^{1-\theta}\right]^{\theta/(\theta-1)}$.

From (3) and (7), we obtain the equilibrium trade value (X_{kij}^*) of good k exported from country *i* to country *j*:

$$X_{kij}^* = \left(\frac{E_j}{\Psi_j}\right)^{\frac{1-\theta}{\sigma-\theta}} \cdot \left(\frac{C_{ki}}{\Pi_{ki}}\right)^{\frac{\sigma-1}{\sigma-\theta}} \cdot \left(\frac{a_{ij}}{\tau_{kj}t_{ij}}\right)^{\frac{(\sigma-1)(1-\theta)}{\sigma-\theta}}$$
(8)

Equation (8) reveals that the Dodd–Frank Act affects the trade value both from demand and supply sides through changes in the evaluation and trade costs, respectively.

3 Empirical Specification

3.1 Data

We use the six-digit 96' HS code classification and the data cover the period from 2000 through 2019. As noted in the introduction, ores and concentrates are classified into Chapter 26, and bars, rods, and wires are classified into Chapter 81. We obtain the bilateral trade flows and other gravity data, such as RTA, from CEPII.¹⁷ We also obtain the data of producing countries of ores and concentrates from the commodity statistics and information on the website of the United States Geological Survey (USGS).¹⁸ We define the countries listed in the information of mine and concentrate productions with positive values at least in one year from 2000 through 2019 as resource-producing countries.¹⁹ As explained later, we adopt a dummy variable for a group of resource-producing countries. The EU conflict mineral regulation was enforced in 2017. However, importers must conduct due diligence from January 2021.²⁰ Moreover, the

¹⁷The URL is http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp.

¹⁸The URL is https://www.usgs.gov/centers/national-minerals-information-center/commodity-statistics-andinformation. The mine (concentrate)-producing countries are listed in the Mineral Commodity Summaries (the Minerals Yearbook) of each resource.

¹⁹When it comes to tantalum, the production statistics were merged with that of niobium before 2015. We do not exclude the period.

²⁰See Partzsch (2018) and the website of the EU (https://ec.europa.eu/trade/policy/in-focus/conflict-minerals-regulation/) for the details of the EU conflict mineral regulation.

Trump administration suspended the Dodd–Frank Act for two years from 2017. However, it is considered that the distribution networks with traceability and due diligence have been already implemented into the transactions and markets. Thus, we do not exclude the period after 2016.

Moreover, we use the data of the number of deaths caused by conflicts provided by the Department of Peace and Conflict Research, Uppsala University.²¹ We adopt the UCDP Georeferenced Event Dataset (GED) Global version 21.1, which provides the yearly data of the number of deaths caused by conflicts within each country. Among them, we use the best (most likely) estimate of total fatalities resulting from events in a certain country each year. We also use the corruption perception index (CPI) provided by Transparency International.²² This index was scored out of 100 (10) from 2012 (until 2011). Thus, the scores before 2012 are multiplied by 10.

3.2 Networks and the focus

The target resources of the Dodd–Frank Act are tantalum, tin, tungsten, and gold (3TG). However, it is difficult to capture trade flows of gold to achieve our goal, that is, to clarify the effect of the trade-restrictive due diligence requirement, because gold is used not only for industrial materials but also for jewelry goods. Gold is also transacted repeatedly for investment purposes. Then, when observing the trading volumes from demand side, the ratio for industrial use is small.²³ Thus, we exclude gold from our analysis.

Next, let us look at the trade structure of ores and concentrates of 3T. Figures 1–3 show the top ten countries in terms of the number of trading partners for ores and concentrates (Chapter 26) of tantalum, tin, and tungsten, respectively. Precisely, *indegree* represents the number of partners from which the country imports the resources, while *outdegree* represents the number of partners to which the country exports the resources. Figures 1(a), 2(a), and 3(a) indicate the trade structure before the Dodd–Frank Act is enforced, while Figures 1(b), 2(b), and 3(b) indicate the corresponding values after the Dodd–Frank Act is enforced. The figures reveal that the trade structures of tantalum and tungsten have important common features: (i) The US and China are the top two countries for both the pre- and post-enforcement periods of the Dodd–Frank Act; (ii) more importantly, both countries are the main importers of these two kinds of resources.

However, the trade structure for tin is different from the first two resources. Although the

²¹The URL is https://www.pcr.uu.se/research/ucdp/ucdp-data/. See Sunberg and Melander (2013) and Pattersson et al. (2021) for the details.

²²The URL is https://www.transparency.org/en/cpi/2021.

²³According to Refinitiv (2019), the ratio of the physical demand for industrial use is smaller than 0.1.

US is ranked second for the pre-enforcement period, it is ranked fourth for the post-enforcement period. The indegree of the US is also very small, that is, the US is not a main importer of ores and concentrates. According to the Commodity Statistics Information of USGS (The Mineral Commodity Summaries of Tin), the US produces a large amount of secondary tin from scraps, and does not import ores and concentrates of tin but products of downstream sectors.²⁴ Moreover, as surveyed by Li et al. (2021), the Great Lakes region is not one of the main extracting regions of tin.²⁵ Thus, we exclude tin from our analysis.

Focusing on tantalum and tungsten, we include the bilateral trade flows of raw materials and intermediates. Resource-producing countries export not only raw materials and intermediates. Moreover, one of the aims of this study is to clarify the degrees of trade diversion and detour trade including those in the downstream sector. Thus, the inclusion of intermediates makes us capture the broader picture of the changes in the trade structure, although we also analyze the bilateral flows of raw materials by including only items in Chapter 26. The precise HS codes we adopt are shown in Table 1.

We consider two points of time that divide pre- and post-enforcement periods. The Dodd– Frank Act passed the US congress in 2010, and the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas was first published in 2011.²⁶ Thus, we first set the boundary point as the end of 2010. However, the US SEC published the finalized rule of disclosure and reporting in mid-2012. The second edition of the OECD due diligence guidance was published in 2013. Thus, we also examine the case in which the boundary point is the end of 2012.²⁷

Finally, we focus on how the Dodd–Frank Act affects trade flows of specific pairs of countries. First, the direct effect is considered to appear on the bilateral trade flows from the DRC or neighboring countries to the US. There are nine neighboring countries: Congo, Central African Republic, South Sudan, Uganda, Rwanda, Burundi, Tanzania, Zambia, and Angola. Not only the DRC but also some of these neighboring countries are resource-extracting ones. Thus, there may exist a substitution effect, that is, the export from the neighboring countries may increase instead of a decrease in the export from the DRC. As noted in the introduction, the imperfections of the registering system of international trade and malfunctioning of monitoring

 $^{^{24}{\}rm This}$ information is provided on the website of USGS. https://www.usgs.gov/centers/national-minerals-information-center/tin-statistics-and-information.

²⁵The USGS summaries also provides the mine production data. In 2019, the ratio of tin mine production in the Great Lakes region to total world mine production was less than 0.05.

 $^{^{26}}$ The third edition is now available: See OECD (2016).

 $^{^{27}}$ We will first examine the case with the boundary point of the end of 2010 in subsections 4.1 and 4.2, and then examine the case with the boundary point of the end of 2012 in subsection 4.3.

by customs may trigger smuggling through neighboring countries. Thus, we distinguish the DRC and neighboring countries. Second, the trade diversion could occur in terms of the target exporting countries. That is, the trade flows from the DRC or neighboring countries to other main importing countries are influenced by the act. As the other main importing countries, we consider three categories: (i) China, (ii) OECD countries other than the US, (iii) Thailand and Vietnam. We consider that OECD countries may have specific features regarding the changes in the behavior and trade flows because consumers in these countries are highly conscious of ethical aspects of economic activities. Figures 1 and 3 also reveal that Thailand and Vietnam are important actors in the trade networks of tantalum and tungsten, respectively.

Third, the trade diversion in terms of the US could also occur. Thus, we also consider the main resource-producing countries other than the US, China, and the target countries of the act, namely, Australia, Bolivia, Brazil, Canada, Ethiopia, Mozambique, Nigeria, Russia, and Zimbabwe for tantalum; Australia, Austria, Bolivia, Brazil, Myanmar, Canada, Democratic People's Republic of Korea, Mongolia, Nigeria, Peru, Portugal, Russia, Spain, and United Kingdom for tungsten.²⁸

Fourth, we also consider the bilateral trade flows between China, Vietnam, or Thailand and the US or OECD countries to capture trade detour.

3.3 Estimation equation

In terms of the structural gravity approach, we estimate the partial effect of the Dodd–Frank Act, which captures the direct effect on bilateral trade flows. Based on Yotov (2016), and using the result of the theoretical setup, the definition of trade cost, and the setup of the estimation strategy in subsection 3.2, the estimation equation for the baseline analysis is given by

$$V_{kijt} = exp \left[\eta_0 r t a_{ijt} + \sum \zeta_{ij} Dodd_{ijt} + \lambda_{kit} + \xi_{kjt} + \chi_{kij} \right] + \epsilon_{kijt}, \tag{9}$$

where, from (2), (6), and (8), we obtain

$$\eta_0 = -\frac{\gamma_0(\sigma - 1)(1 - \theta)}{\sigma - \theta},\tag{10}$$

$$\zeta_{i,j} = \frac{(\alpha_{i,j} - \gamma_{i,j})(\sigma - 1)(1 - \theta)}{\sigma - \theta}.$$
(11)

Moreover, λ_{kit} is a set of time-varying exporter fixed effects, ξ_{kjt} is a set of time-varying importer fixed effects, and χ_{kij} is a set of time-invariant pair fixed effects. As there are many zero trade

²⁸According to Figure 1, South Africa seems to be an important player in the trade network of resources. However, it is one of main producing countries of vanadium. The HS code of 261590 includes not only tantalum but also vanadium. However, vanadium is not the focus of this study. Hence, we exclude South Africa from the group of tantalum-producing countries.

values, we adopt Poisson pseudo maximum likelihood (PPML). Standard errors of all estimations are clustered by exporter, importer, and HS code. We focus on the pairs of the main exporting and importing countries explained in subsection 3.2.

4 Results

4.1 Baseline results

Let us begin the description of the baseline estimations, in which $Dodd_{ijt}$ in the estimation equation takes the value 1 (i) if the bilateral trade flow is the export from country *i* to country *j* and (ii) if the year is 2011 or after, and 0 otherwise. The results are shown in Table 2. Otherp denotes the other producing countries listed up in subsection 3.2. The first three estimations (columns) include all items of tantalum and tungsten including those categorized into both Chapters 26 and 81 of HS classification. The estimations from columns 4 to 6 include only the data of ores and concentrates, which implies that only the bilateral trade flows classified into the six-digit HS codes of 261590 and 261100 are included. Moreover, the estimations from columns 7 to 9 (10 to 12) focus on the trade flows of tantalum (tungsten). Note that VT includes both Vietnam and Thailand for the first six estimations, but includes only Thailand (Vietnam) in the estimations from columns 7 to 9 (10 to 12). As the frequency of the tungsten export from the DRC to the US and other OECD countries is low and the volume is also small, the terms corresponding to the bilateral trade flows of those pairs are dropped from the estimation of tungsten.

The clearest result for the estimations from columns 1 to 9 is that the trade flows from the DRC to the US decreased after the Dodd–Frank Act was enforced. The main cause is considered the cost increase of importation from the DRC following the due diligence requirement, which corresponds to a positive value of γ_{ij} in (11). The higher possibility that imported raw materials and intermediates are contaminated with conflict ones also leads to a cost increase for firms that must avoid negative evaluation from buyers and consumers, which corresponds to a negative value of α_{ij} in (11).

There are two other common trends. First, the trade flows from the DRC to OECD countries decreased. Similar to US society, people's interest in CSR has grown in other developed countries. Responding to this trend, the EU passed regulations on trade in conflict minerals in 2017 to promote the responsible sourcing of resources by firms that supply their products to the EU market.²⁹ Many firms also have business relationships with US firms in these countries. Thus,

²⁹For the details, see the page of this regulation in the website of European Commission:

the trade flows from the DRC to OECD countries decreased after the Dodd–Frank Act was enforced in parallel with the change in the trade flows from the DRC to the US.

Second, the trade flows from the neighboring countries to Thailand and Vietnam increased. This does not necessarily mean that these two countries import more conflict resources compared with the pre-enforcement period. However, it indicates that the trade diversion effect arises and the global trade and production networks have changed.

When we focus on the last six estimations, there is sharp contrasts between trade flows of tantalum and tungsten. The trade flows from the neighboring countries to the US increased (decreased) for tantalum (tungsten), while the corresponding values to China decreased (increased) for tantalum (tungsten). These signs of coefficients indicate the substitutability between the US and China as destination countries of exports from the target region in Central Africa.

There may exist the other type of substitutability. The DRC is one of the main extraction countries of tantalum, but not for tungsten. Contrarily, Rwanda, a neighboring country, is one of the main extraction countries for both tantalum and tungsten. The Dodd–Frank Act is considered to have negative effects on the exports of 3TG from both the DRC and Rwanda because both of the two countries are target countries of the act and the cost for the due diligence requirements increases. However, the exports of the DRC are expected to be more severely influenced than that of Rwanda during the period covered by the data because conflicts in the DRC were much more serious than those in Rwanda. Then, there may be substitutability between the DRC and Rwanda as source countries of resources in terms of the foreign importers. In the case of tantalum, the trade from the DRC decreased drastically owing to the enforcement of the Dodd–Frank Act, and accordingly, the substitution effect is considered to dominate the negative trade effect for Rwanda. However, in the case of tungsten, the export value from the DRC is small even in the pre-enforcement period. Thus, the substitution effect is small, and the negative trade effect of the cost increase for meeting the due diligence requirement for Rwanda is considered to dominate the substitution effect.

There are two possible sources of the substitution effect for the increase in the tantalum trade flows from the neighboring countries to the US: the occurrence of trade diversion and smuggling. In the former case, two factors can increase the neighboring countries' tantalum export: (i) increases in extraction and (ii) redirection of exports from China to the US. If all of the substitution effect is attributable to smuggling, the exports from the neighboring countries to China are not expected to decrease. However, because the degrees of the increase of trade

 $https://policy.trade.ec.europa.eu/development-and-sustainability/conflict-minerals-regulation_en.$

flows to the US is greater than those to China, it is also possible that smuggling has increased. Thus, both trade diversion and smuggling may contribute to a substitution effect. Although we refer to trade diversion for interpreting the increases in the trade flows from the neighboring countries to Thailand and Vietnam, smuggling may also contribute the increases. ³⁰

Moreover, the trade flows from the other main importing country of ores and concentrates, Thailand or Vietnam, to the US and OECD countries decreased (increased) in the post-enforcement period for tantalum (tungsten). The possible reason for tantalum is that the exports from these two countries to the other center of the manufacturing processes, China. Another possible reason is that the exports of the products in the downstream sectors from these two countries to the US and OECD increased, which implies the expansion of resource refining and manufacturing sectors in Thailand. For tungsten, because Vietnam is also one of producing countries, the substitution effect may cause the increase in trade flows: the US imports of tungsten from Vietnam increased instead of a decrease in imports from the neighboring countries of DRC. Detour trade may also lead to this increase in the trade flow from Thailand to the US. The increase in the trade flow from the neighboring countries to Thailand indicates this possibility.

4.2 Relationship with conflict scales and victims

Next, we examine if the Dodd–Frank Act has eliminated the relationship between trade flows and conflicts. In terms of the costs of due diligence and risks, the more serious the conflicts in the target countries, the more costly it is to import resources from those countries. This is because, as the conflicts become more serious, (i) the possibility that resources imported from the target countries are contaminated with conflict resources may become higher, (ii) the number of certified extracting firms or the volumes of resources those extracting firms can procure may become smaller, and (iii) when the situation in the target countries regarding conflicts and violence is widely known in the society of importing countries, the risk that importing firms receive a negative evaluation in the market becomes higher.

The estimation equation (9) is thus changed:

$$V_{kijt} = exp \left[\eta_0 rta_{ijt} + \sum \mu_{ij} Victim_{ijt} + \sum \zeta_{ij} Dodd_{ijt} + \sum \nu_{ij} Victim_{ijt} \times Dodd_{ijt} + \lambda_{kit} + \xi_{kjt} + \chi_{kij} \right] + \epsilon_{kijt}, \quad (12)$$

We focus on the country pairs whose exporting countries are the DRC or neighboring countries. $Victim_{ij}$ represents two types of numbers of death caused by conflicts. First, it is the number of

³⁰As we shall describe in the final section, it is the next step to quantify these two sources.

deaths caused by conflicts within the territory of each exporting country *i*. For example, when the exporting country is Rwanda, $Victim_{Rwanda,jt}$ is the number of deaths in year *t* within the territory of Rwanda.

Second, it is the number of deaths caused by conflicts in the DRC. For example, when the exporting country is Burundi, $Victim_{Burundi,jt}$ is the number of deaths in year t within the territory of the DRC. However, the main aim of the Dodd–Frank Act is the decrease in conflicts and the protection of human rights in the DRC. The neighboring countries are included in the target country group because certain quantities of 3TG are exported from the DRC through the neighboring countries, and they are often registered as the exports of these neighboring countries. Thus, we also consider the relationship between the numbers of deaths caused by conflicts within the DRC and the exports of neighboring countries. The trend and summary stats of the numbers of deaths of the target countries are shown in Figure 4 and Table $3.^{31}$

Moreover, to extract the effect of the Dodd–Frank Act, we examine if the relationship between the trade values and the conflicts in the post-enforcement is different from that in the preenforcement period. Thus, $Victim_{ijt} \times Dodd_{ijt}$ takes the value of 0 if year is 2010 or before, while it is equal to $Victim_{ijt}$ if year is 2011 or after.

The estimation results are shown in Table 4. Having observed the baseline results, the effect of conflicts in the DRC cannot be extracted when using only the trade data of tungsten. Thus, we adopt three estimations, each of which uses the items of (i) Chapters 26 and 81 of both tantalum and tungsten (*all*), (ii) Chapter 26 of both tantalum and tungsten (*raw*), or (iii) Chapters 26 and 81 of tantalum (*tantalum*). The first three estimations (columns 1 to 3) use the first definition of $Victim_{ijt}$, which is the number of deaths within each exporting country, while the last three estimations (columns 4 to 6) use the second definition of $Victim_{ijt}$, which is the number of deaths within the DRC. We focus on the post-enforcement period, that is, the coefficients of $Victim_{ijt} \times Dodd_{ijt}$.

There are three common results. First, when it comes to the trade flows from the DRC, the Dodd–Frank Act has weakened the positive relationship between the trade flows and the conflicts. In particular, this trend is clearly observed for the trade flows from the DRC to OECD countries. The coefficients of the cross terms are larger than those of $Victim_{DRC,OECD}$, which implies that the sign of the relationship changed after 2010. Second, when we focus on the number of deaths of each exporting country (columns 1 to 3), the relationship between the trade flows and the conflicts has also been weakened for the exports of the neighboring countries. These

³¹We provide the corresponding numbers of the average of OECD countries as a basis for comparison.

results indicate that the Dodd–Frank Act also has the intended effect, which is the dissolution of the relationship between the conflicts and resource exports, not only on the DRC but also on the neighboring countries.

Third, when we focus on the number of deaths in the DRC (columns 4 to 6), two coefficients of the cross terms regarding the exports from the neighboring countries are significantly positive: the exports to the US and the group of Thailand and Vietnam. We surmise that this is because (i) the substitution effect arises regarding legal trade and extraction: the neighboring countries increase their exports instead of the DRC; and (ii) a detour trade arises and resources originally extracted in the DRC may be registered as the export of the neighboring countries. Although the malfunctioning of monitoring system of each country is excluded by the set of fixed effects, the time-varying illegal trading routes for the specific trading pairs may be reflected in the results.

4.3 The Other Possible Timing of Enforcement

As described in subsection 3.2, the SEC published the finalized rule of disclosure and reporting in mid-2012. The second edition of the OECD due diligence guidance was published in 2013. Thus, we also examine the case in which the boundary point is assumed to be the end of 2012. We conduct the same estimations as in subsections 4.1 and 4.2. The results are shown in Tables 5 and 6. Similar to Table 2, as the frequency of the tungsten export from the DRC to the US and other OECD countries is low and the volume is also small, the terms corresponding to the bilateral trade flows of those pairs are dropped from the estimation of tungsten in Table 5. Similar to Table 4, we do not show the estimation result using only the data of tungsten in Table 6.

Let us compare the baseline results of both timings of enforcement. The two core results are the same as those in subsection 4.1. First, the trade flows from the DRC to the US and OECD countries decreased after the Dodd–Frank Act was enforced. Second, there is a sharp contrast regarding the export from the neighboring countries to the US and China between tantalum and tungsten: The trade flow of tantalum to the US (China) increased (decreased), whereas the trade flow of tungsten to the US (China) decreased (increased) in the post-enforcement period compared with the pre-enforcement period.

However, there are also differences between the two baseline results. First, the sizes of the negative coefficients in the results with the boundary point of the end of 2012 are smaller than those with the boundary point of the end of 2010. As Schütte (2019) pointed out, the difference in the sizes indicates the existence of the rebound effect: (i) from a positive perspective, firms

in the developed countries overestimated the cost of due diligence and overreacted to the act for the first few years. Then, after a few years passed, the rules became clear, and they began estimating the risk and costs appropriately; (ii) from a negative perspective, the effectiveness of the Dodd–Frank Act is reduced for some reasons such as the development of new smuggling routes.³²

Second, the trade diversion in terms of supply side has become clear: The trade flows from the other producing countries (Otherp) to the US increased after 2012. This fact indicates that new distribution channels were developed between the US and the other producing countries after the enforcement of the Dodd–Frank Act.

Third, China increased its importance in the global supply networks of these resources as time advanced after 2010. For example, the coefficients of the trade flows from the DRC to China became more significant, and the trade flows from China to the US and OECD countries became significantly positive after 2012. These facts indicate that trade-restrictive regulations may restructure the supply chain structure around the world.

Fourth, the effects on the trade flow of tungsten from Vietnam to the US, the substitution effect and detour trade, became insignificant in the post-enforcement period. This change in the trade flow also indicates (i) an increase in the presence of China in the trading networks of tungsten and (ii) the expansion of resource refining and manufacturing sectors in Vietnam and increases in the exports of the products in the downstream sectors from Vietnam to the US.

Next, we compare the results on the relationship between the trade flows and conflicts. Similar to subsection 4.2, we focus on the post-enforcement period, that is, the coefficients of $Victim_{ijt} \times Dodd_{ijt}$. All results with the boundary point of the end of 2012 are the same as those with the boundary point of the end of 2010. The significant coefficients are negative except for the coefficient of the victim in the DRC regarding (i) the trade flows from the neighboring countries to Thailand and Vietnam and (ii) the trade flows of tantalum from the neighboring countries to the US. The negative coefficients indicate that the Dodd–Frank Act reduced the relationship between the trade and conflicts even after 2012, whereas the few positive coefficients imply that the trade diversion/substitution effects rose.³³ Moreover, the comparisons of the two results, after 2010 and after 2012, reveal that the magnitudes of the values of those negative coefficients are not very different from each other. In some cases, the magnitudes are greater

 $^{^{32}}$ More case studies and micro-data analyses on firms' behavior are needed to clarify the causes of this rebound effect.

³³As noted in subsection 4.1, there exist two possible sources of the substitution effect: an increase in the extraction in the neighboring countries and an increase in smuggling. In the latter case, the effectiveness of the Dodd–Frank Act in terms of the dissolution of the relationship between trade and conflicts is reduced.

in the results of *after 2012* than in the results of *after 2010*. This fact implies that, in the relationship between the trade and conflicts, a clear rebound effect is not observed.

4.4 Extension: Relationship with corruption

As noted in the previous sections, smuggling is an important issue when considering conflict resources. The Dodd–Frank Act is expected to negatively affect the transactions of conflict resources and to reduce the conflicts and violence by choking off the source of funds to armed groups. However, the act is also expected to have a side effect: it may increase illegal transactions and lead to an expansion of the black market. Although it is extremely difficult to capture the magnitude of the side effect directly, we indirectly examine the effect of the Dodd–Frank Act on illegal activities such as laundering.

According to Transparency International, the DRC has been one of the countries that has ranked poorly on the CPI since it was evaluated in 2004 for the first time. It is generally considered that smuggling has a close relationship with the degree of corruption because corruption in the customs leads to the malfunction of monitoring systems at the national borders. Thus, we consider that, if the Dodd–Frank Act produces the side effect, the trade flows from the DRC or neighboring countries to other countries with relatively low CPI-score significantly increase in the post-enforcement period as compared with the pre-enforcement period. Thus, we introduce the differences between the CPI of the exporting and importing countries as an explanatory variable $(Dcpi_{ij})$, which is defined as $CPI_i - CPI_j$, and focus on the export from the DRC or neighboring countries.

The estimation equation (9) is changed as follows.

$$V_{kijt} = exp \left[\eta_0 r t a_{ijt} + \sum \mu_{ij} D c p i_{ijt} + \sum \zeta_{ij} D o d d_{ijt} + \sum \nu_{ij} D o d d_{ijt} \times D c p i_{ijt} + \lambda_{kit} + \xi_{kjt} + \chi_{kij} \right] + \epsilon_{kijt},$$
(13)

In this estimation, we focus on the DRC and neighboring countries as exporting countries (country i).

The results are shown in Table 7. We obtain two especially important findings: First, there was a change in the relationship between CPI and trade flows after around 2010, which is captured by the significant coefficients of the cross terms (ν_{ij}). Second, when the coefficients of the cross-terms are significant, they are positive, which implies that the exports from the DRC and neighboring countries to the countries with low-scored CPI became greater than to those with high-scored CPI after 2010. Except for tungsten, the correlation between the difference in the CPI scores and the trade values before 2011 is negative. Thus, the positive coefficients of

the cross-terms imply changes in the relationship after 2010, which indicates the possibility that corruption in the trade of tantalum and tungsten from the DRC and neighboring countries has increased, which may lead to an increase in smuggling through the countries with low CPI-scores.

4.5 Discussion

Now let us summarize and discuss the estimation results in terms of four important aspects. First, our baseline results are consistent with the literature (ex. Schütte, 2019; Schütte and Näher, 2020). It is widely known that the due diligence requirement of the Dodd–Frank Act produced a negative effect on trade flows from the target countries to the US. Moreover, it is a common view that the act led to trade diversion effects. In other words, ores and concentrates of tantalum and tungsten were directed to China, Thailand, and Vietnam instead of the US after the act was enforced. Thus, our estimation results confirm that the surge of awareness of the protection of the environmental and human rights can affect the global supply chain under the condition of the government's measures.

Second, we obtain additional results. The trade flows from the DRC and neighboring countries to OECD countries other than the US also decreased after 2010. Because many consumers and firms in the OECD countries are also highly conscious of the environment and human rights, their behavior is considered to change during this period. However, because many firms in these countries have transaction relationships with US firms, it is likely that the Dodd–Frank Act also influenced the trade flows from the target countries of the act to OECD countries. Regarding detour trade, there is a sharp contrast between China and other South-East Asian countries (Thailand and Vietnam). The trade flows from China to the US or OECD countries increased in the post-enforcement period, whereas those from Thailand and Vietnam decreased. As described in subsection 4.3, it is possible that the exports from these two countries to China increased. Our results indicate that the global supply chain has changed after 2010; in particular, the importance of China in the supply chain has increased. To support this remark, we conduct network analysis and detect clusters for tungsten trade. Figures 5(a) and (b) show the cluster structure has changed and that the cluster with China has expanded during this period.³⁴

Third, we obtain significant results regarding the change in the relationship between trade flows and conflicts, which was not comprehensively captured in the literature. Generally, the

 $^{^{34}\}mbox{The communities detected with "cluster_optimal" function in "igraph" package in statistical software R, which calculates the optimal community structure of a graph, by maximizing the modularity measure over all possible partitions. See https://igraph.org/r/doc/cluster_optimal.html$

relationship weakened after 2010. Similar to the causes of the decrease in trade from the target countries to OECD countries, the increase in awareness of ethical issues and firms' behavioral changes toward strict due diligence during this period is reflected in the change of the relationship between trade and conflicts. However, the trade-restrictive measures, such as the due diligence requirement of the Dodd–Frank Act, are considered to have a significant influence. The important point is that, different from the baseline results on the changes in trade values, the clear rebound effect is not observed about the dissolution of the relationship between trade and conflicts. Regarding the exports from the target countries of the Dodd–Frank Act to the main importing countries, the act generates the intended effect to reduce the relationship between the trade and conflicts.

Fourth, we find that the exports from the DRC and neighboring countries to the countries with low-scored CPI increased than to those with high-scored CPI after 2010. We focus on the pairs between the target countries and the main importing countries in the estimations with victims of conflicts (subsection 4.2). In such cases, the Dodd–Frank Act may have succeeded in its goal. However, the results with CPI indicate that smuggling and laundering may increase through importing countries with low CPI scores, and these are not major importing countries such as the US, China, Thailand, and Vietnam, and OECD members. In this respect, our findings stress the importance of multilateral efforts that include not only the main importers of raw materials and intermediates but also minor importers.

5 Conclusion

Using the gravity approach, we examined the effect of the Dodd–Frank Act on bilateral trade flows and the relationship between trade and conflicts. In the presence of the relationship between conflicts and revenue from resource extraction, it is important to design institutions to break this relationship. Although the Dodd–Frank Act can generate the intended effect, countries are limited in taking unilateral actions owing to trade diversions and detour trades. Only implementing measures that influence international trade are insufficient. Proper industrial and environmental policies at the extraction region are indispensable. For example, Seay (2012) examined the domestic political situation in the DRC related to conflict minerals. Diemel and Hilhorst (2019) demonstrated that the Dodd–Frank Act and OECD due diligence requirement guidance may achieve the procurement of conflict-free resources but may not contribute to peace. It is also necessary to establish strict monitoring and traceability systems. For example, Young et al. (2019) shed light on the multi-tier supply chains of resources, and referred to the traceability scheme for key players that are referred to as *deep suppliers*. Implementing these policies and systems is costly, particularly for developing countries. Hence, the cooperative mechanism should be developed. As noted in the introduction, our analysis also contributes to this issue by clarifying the relationship between the CPI scores and trade values.

The points above are also the limitation of this study, which require both theoretical and empirical exploration. For example, using the micro-data of resource extracting and importing firms, and transaction relationships between those firms, it would be interesting to clarify the effect of due diligence requirement not only on trade flows but also on firms' behavior. In 2021, the EU enforced a similar regulation on conflict minerals. It is more multilateral in the sense that it covers more exporting and importing countries. However, the target products are focused upon more narrowly. A comparison of more than one regulation may reveal additional important facts. It is also important to disaggregate the substitution effect between the DRC and neighboring countries and quantify the extraction increasing effect and the smuggling effect to comprehend the effectiveness of the trade restrictive measures regarding conflict resources. Thus, still, many issues about conflict minerals need to be resolved.

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Resources	HS code	Item
Tantalum	261590	Niobium, tantalum, vanadium ores and concentrates
	810310	Tantalum: unwrought, including bars and rods obtained simply
		by sintering, waste and scrap, powders
	810390	Tantalum: articles n.e.s. in heading no. 8103
Tungsten	261100	Tungsten ores and concentrates
	810110	Tungsten (wolfram): articles thereof, including waste and scrap, powders
	810191	Tungsten (wolfram): unwrought, including bars and rods
		obtained simply by sintering, waste and scrap
	810192	Tungsten (wolfram): bars and rods, other than those obtained simply
		by sintering, profiles, plates, sheets, strip and foil
	810193	Tungsten (wolfram): wire
	810199	Tungsten (wolfram): articles n.e.s. in heading no. 8101

Table 1: HS codes and items included in the estimation.

				Tal	ole 2. Baselin	e Results						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	All	All	All	Raw	Raw	Raw	Tantalum	Tantalum	Tantalum	Tungsten	Tungsten	Tungsten
rta	-0.462**	-0.459**	-0.420*	0.362*	0.375*	0.426**	-0.598	-0.604	-0.523	-0.315***	-0.306***	-0.304***
	(0.203)	(0.202)	(0.237)	(0.219)	(0.192)	(0.195)	(0.423)	(0.424)	(0.427)	(0.085)	(0.088)	(0.113)
Dodd_(DRC, US)	-1.732***	-1.500***	-2.809***	-1.624***	-1.854***	-2.839***	-1.828***	-1.637***	-3.564***			
	(0.278)	(0.241)	(0.336)	(0.316)	(0.297)	(0.407)	(0.179)	(0.163)	(0.229)			
Dodd_(DRC, China)	0.656	0.703	-0.382	0.702	0.724	-0.404	0.182**	0.057	-1.598***	3.460***	3.873***	3.809***
	(0.485)	(0.500)	(0.767)	(0.715)	(0.799)	(1.261)	(0.087)	(0.143)	(0.186)	(0.074)	(0.261)	(0.288)
Dodd_(Neighbor, US)	-0.261	-0.032	0.409	-0.242	-0.474	0.320	0.550***	0.740***	1.250***	-1.399***	-1.177***	-0.749**
	(0.320)	(0.424)	(0.842)	(0.657)	(1.180)	(1.447)	(0.113)	(0.149)	(0.163)	(0.058)	(0.165)	(0.379)
Dodd_(Neighbor, China)	-0.143	-0.097	0.531	-0.123	-0.099	0.502	-0.520***	-0.646***	0.044	1.087***	1.562***	1.799***
	(0.465)	(0.470)	(0.496)	(0.581)	(0.583)	(0.468)	(0.125)	(0.125)	(0.170)	(0.049)	(0.170)	(0.336)
Dodd_(Otherp, US)		0.295	0.239		-0.281	0.003		0.209	0.080		0.344	0.457
		(0.268)	(0.308)		(0.684)	(0.467)		(0.298)	(0.318)		(0.311)	(0.310)
Dodd_(Otherp, China)		0.087	0.196		0.032	-0.088		-0.232	-0.149		0.656***	0.580**
		(0.178)	(0.262)		(0.169)	(0.203)		(0.208)	(0.241)		(0.163)	(0.243)
Dodd_(DRC, OECD)			-5.085***			-5.192***			-5.865***			
			(0.401)			(0.832)			(0.286)			
Dodd_(Neighbor, VT)			4.029***			4.062***			4.182***			2.631***
			(0.298)			(0.289)			(0.245)			(0.302)
Dodd_(Neighbor, OECD)			0.619			0.619			0.765***			0.379
			(0.457)			(0.461)			(0.257)			(0.263)
Dodd_(China, US)			0.173			-0.172			0.231			0.112
			(0.173)			(0.667)			(0.297)			(0.372)
Dodd_(China, OECD)			0.230			1.116**			0.508			-0.101
			(0.193)			(0.488)			(0.340)			(0.234)
Dodd_(VT, US)			-1.518			0.973			-3.254***			1.848***
			(0.939)			(0.658)			(0.296)			(0.458)
Dodd_(VT, OECD)			-1.635*			-1.300			-3.315***			0.854
			(0.869)			(1.743)			(0.435)			(0.759)
N	251888	251888	251888	30897	30897	30897	57020	57020	57020	194868	194868	194860
R-sq	0.914	0.914	0.916	0.933	0.933	0.936	0.905	0.905	0.909	0.938	0.938	0.938
Exporter-hscode-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer-hscode-year fixed efects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-importer-hscode fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11	-1.103e+07	-1.103e+07	-1.094e+07	-3222590.898	-3221937.237	-3166689.691	-5915143.758	-5914003.553	-5777941.737	-5091626.681	-5084978.962	-5078319.121

- Values in the parentheses are standard errors clustered by exporter, importer, hscode. - ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

	Max	Min	Average	Median	StDev
Democratic Republic of the Congo	7908	312	2336.2	1790	2029.75
Angola	2154	0	212.5	24.5	539.93
Zambia	7	0	0.4	0	1.57
United Republic of Tanzania	37	0	2.4	0	8.27
Burundi	2071	0	417.4	97.5	615.62
Rwanda	2044	0	107.3	0	455.92
Uganda	2004	0	400.85	45.5	639.18
South Sudan	2491	0	596.05	0	761.51
Central African Republic	3396	6	625.55	192.5	1025.13
Congo	234	0	18.1	0.5	52.58
OECD_Average	410	2.07	89.64	79.98	100.88

Table 3. Summary statistics of the numbers of deaths caused by conflicts from 2000 to 2019

Table 4. Relationship with Conflicts

	(1)	(2)	(3)	(4)	(5)	(6)
	All	Raw	Tantalum	All	Raw	Tantalum
Victim_(DRC, US)	0.0001	0.0002	0.0006***	0.0001	0.0002	0.0006***
	(0.0002)	(0.0003)	(0.0001)	(0.0002)	(0.0003)	(0.0001)
Dodd_Victim_(DRC, US)	0.0001	0.0000	-0.0004***	-0.0002	0.0001	-0.0004***
	(0.0003)	(0.0003)	(0.0001)	(0.0002)	(0.0003)	(0.0001)
Victim_(DRC, China)	0.0008***	0.0009***	0.0010***	0.0008***	0.0009***	0.0010***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0000)
Dodd_Victim_(DRC, China)	-0.0003*	-0.0005***	-0.0006***	-0.0003***	-0.0005***	-0.0007***
	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0002)	(0.0001)
Victim_(Neighbor, US)	-0.0006	-0.0007	-0.0003***	-0.0002	-0.0003	-0.0003***
	(0.0004)	(0.0004)	(0.0000)	(0.0001)	(0.0002)	(0.0001)
Dodd_Victim_(Neighbor, US)	0.0027	0.0024	-0.0023***	0.0003	0.0003	0.0004***
	(0.0134)	(0.0135)	(0.0009)	(0.0002)	(0.0003)	(0.0001)
Victim_(Neighbor, China)	-0.0011***	-0.0011**	-0.0013***	0.0000	-0.0000	-0.00002*
	(0.0003)	(0.0005)	(0.0001)	(0.0001)	(0.0001)	(0.00001)
Dodd_Victim_(Neighbor, China)	-0.0064	-0.0067	-0.0089***	-0.0001	-0.0001	-0.0002***
	(0.0075)	(0.0074)	(0.0016)	(0.0001)	(0.0003)	(0.0000)
Victim_(DRC, OECD)	0.0008***	0.0011***	0.0013***	0.0008***	0.0011***	0.0013***
	(0.0001)	(0.0002)	(0.0000)	(0.0001)	(0.0002)	(0.0000)
Dodd_Victim_(DRC, OECD)	-0.0011***	-0.0019***	-0.0021***	-0.0011***	-0.0018***	-0.0021***
	(0.0002)	(0.0004)	(0.0001)	(0.0001)	(0.0003)	(0.0001)
Victim_(Neighbor, VT)	0.0011***	0.0011***	0.0012***	0.0001	0.0001	-0.0004***
	(0.0002)	(0.0003)	(0.0001)	(0.0003)	(0.0004)	(0.0001)
Dodd_Victim_(Neighbor, VT)	-0.0066	-0.0066	-0.0055***	-0.0001	-0.0001	0.0004***
	(0.0065)	(0.0065)	(0.0014)	(0.0003)	(0.0004)	(0.0001)
Victim_(Neighbor, OECD)	-0.0000	0.0000	0.0000	-0.0000	-0.0000	-0.0000
	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0000)
Dodd_Victim_(Neighbor, OECD)	-0.0117*	-0.0122	-0.0135***	-0.0002	-0.0002	-0.0002***
	(0.0064)	(0.0074)	(0.0021)	(0.0001)	(0.0001)	(0.0001)
Ν	251888	30897	57020	251888	30897	57020
R-sq	0.915	0.937	0.907	0.915	0.936	0.906
Control	rta, Dodd(i,j)	rta, Dodd_(i,j)				
Exporter-hscode-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Importer-hscode-year fixed efects	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-importer-hscode fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
11	-10964003	-3154890.551	-5849387.691	-10972179	-3163272.699	-5858006.156

- Values in the parentheses are standard errors clustered by exporter, importer, hscode. - ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	all	all	all	raw	raw	raw	tantalum	tantalum	tantalum	tungsten	tungsten	tungsten
rta	-0.462**	-0.454**	-0.443**	0.358*	0.339*	0.365***	-0.600	-0.604	-0.587	-0.315***	-0.296***	-0.295**
	(0.201)	(0.206)	(0.222)	(0.193)	(0.176)	(0.134)	(0.418)	(0.451)	(0.469)	(0.083)	(0.104)	(0.116)
Dodd_(DRC, US)	-0.944***	-0.555***	-0.614***	-0.870***	0.010	-0.091	-0.976***	-0.371**	-0.459***			
	(0.083)	(0.180)	(0.141)	(0.110)	(0.202)	(0.267)	(0.107)	(0.189)	(0.160)			
Dodd_(DRC, China)	1.246***	1.218***	1.194***	1.279***	1.327***	1.313***	0.927***	0.927***	0.910***	3.439***	3.342***	3.435***
	(0.330)	(0.261)	(0.347)	(0.473)	(0.381)	(0.458)	(0.031)	(0.063)	(0.098)	(0.075)	(0.187)	(0.273)
Dodd_(Neighbor, US)	-0.270*	0.115	0.871*	-0.262	0.614*	1.355**	0.163	0.758***	1.602***	-0.750***	-0.395	0.096
	(0.162)	(0.168)	(0.471)	(0.342)	(0.320)	(0.593)	(0.116)	(0.167)	(0.200)	(0.048)	(0.259)	(0.500)
Dodd_(Neighbor, China)	-0.510	-0.543	0.269	-0.489	-0.444	0.410	-0.965***	-0.966***	-0.085	0.993***	0.998***	1.533***
	(0.537)	(0.491)	(0.485)	(0.696)	(0.606)	(0.563)	(0.124)	(0.129)	(0.168)	(0.039)	(0.116)	(0.379)
Dodd_(Otherp, US)		0.465***	0.495**		1.075***	1.005***		0.736**	0.653**		0.435*	0.536*
		(0.150)	(0.196)		(0.074)	(0.212)		(0.337)	(0.306)		(0.193)	(0.286)
Dodd_(Otherp, China)		-0.043	0.027		0.100	0.150		0.007	0.017		0.036	0.124
		(0.194)	(0.145)		(0.224)	(0.183)		(0.155)	(0.178)		(0.130)	(0.190)
Dodd_(DRC, OECD)			-2.747***			-2.729***			-2.785***			
			(0.352)			(0.257)			(0.428)			
Dodd_(Neighbor, VT)			4.505***			4.527***			5.219***			1.830***
			(0.967)			(1.230)			(0.341)			(0.338)
Dodd_(Neighbor, OECD)			0.812*			0.909*			1.080***			0.487
			(0.424)			(0.485)			(0.192)			(0.328)
Dodd_(China, US)			0.454**			1.057***			0.545**			0.379
			(0.200)			(0.134)			(0.225)			(0.415)
Dodd_(China, OECD)			0.296			3.384***			0.532*			0.068
			(0.209)			(0.300)			(0.320)			(0.171)
Dodd_(VT, US)			-1.115***			-0.360			-1.434***			-0.933
			(0.314)			(0.353)			(0.351)			(0.780)
Dodd_(VT, OECD)			-1.073***			-1.909			-1.442***			-0.178
			(0.431)			(1.436)			(0.425)			(0.757)
N	251888	251888	251888	30897	30897	30897	57020	57020	57020	194868	194868	194861
R-sq	0.914	0.914	0.917	0.934	0.935	0.939	0.905	0.906	0.909	0.937	0.938	0.939
Exporter-hscode-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Importer-hscode-year fixed efects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-importer-hscode fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11	-1.102e+07	-1.101e+07	-1.092e+07	-3213412.854	-3205830.892	-3124903.735	-5902832.325	-5900205.989	-5795624.163	-5097496.513	-5091651.976	-5082760.032

Table 5. Baseline Results (The boundary point of time is the end of 2012)

- Values in the parentheses are standard errors clustered by exporter, importer, hscode. - ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	all	raw	tantalum	all	raw	tantalum
Victim_(DRC, US)	0.0004*	0.0004	0.0007***	0.0004**	0.0003	0.0006***
	(0.0003)	(0.0003)	(0.0000)	(0.0002)	(0.0003)	(0.0000)
Dodd_Victim_(DRC, US)	-0.0004	-0.0003	-0.0006***	-0.0003*	-0.0002	-0.0005***
	(0.0002)	(0.0003)	(0.0000)	(0.0002)	(0.0002)	(0.0000)
Victim_(DRC, China)	0.0009***	0.0008***	0.0009***	0.0009***	0.0008***	0.0008***
	(0.0001)	(0.0002)	(0.0000)	(0.0001)	(0.0001)	(0.0000)
Dodd_Victim_(DRC, China)	-0.0006***	-0.0005**	-0.0006***	-0.0006***	-0.0006***	-0.0006***
	(0.0001	(0.0002)	(0.0000)	(0.0001)	(0.0002)	(0.0000)
Victim_(Neighbor, US)	-0.0006**	-0.0006**	-0.0004***	-0.00019	-0.0002	-0.0003***
	(0.0003)	(0.0003)	(0.0001)	(0.00021)	(0.0002)	(0.0001)
Dodd_Victim_(Neighbor, US)	0.0019	0.0017	-0.0026	0.0002	0.0002	0.0003***
	(0.0068)	(0.0093)	(0.0019)	(0.0003)	(0.0004)	(0.0000)
Victim_(Neighbor, China)	-0.0012***	-0.0012***	-0.0013***	-0.0000	-0.0000	-0.00003***
	(0.0002)	(0.0003)	(0.0001)	(0.0001)	(0.0001)	(0.00001)
Dodd_Victim_(Neighbor, China)	-0.0062	-0.0065	-0.0078***	-0.0000	-0.0000	-0.0001***
	(0.0038)	(0.0041)	(0.0030)	(0.0003)	(0.0003)	(0.0000)
Victim_(DRC, OECD)	0.0012**	0.0011***	0.0012***	0.0011***	0.0011***	0.0010***
	(0.0001)	(0.0002)	(0.0000)	(0.0001)	(0.0001)	(0.0000)
Dodd_Victim_(DRC, OECD)	-0.0017***	-0.0013***	-0.0018***	-0.0018***	-0.0013***	-0.0013***
	(0.0002)	(0.0004)	(0.0001)	(0.0002)	(0.0002)	(0.0001)
Victim_(Neighbor, VT)	0.0011**	0.0011	0.0015***	-0.0000	-0.0001	-0.0004***
	(0.0005)	(0.0007)	(0.0001)	(0.0003)	(0.0003)	(0.0001)
Dodd_Victim_(Neighbor, VT)	-0.0082	-0.0081	-0.0079***	-0.0002	-0.0001	0.0002***
	(0.0050)	(0.0053)	(0.0015)	(0.0003)	(0.0002)	(0.0001)
Victim_(Neighbor, OECD)	-0.0000	0.0000	-0.0000	-0.0000	-0.0000	-0.0001***
	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0000)
Dodd_Victim_(Neighbor, OECD)	-0.0134**	-0.0137**	-0.0156***	-0.0002	-0.0002	-0.0003***
	(0.0061)	(0.0065)	(0.0026)	(0.0002)	(0.0002)	(0.0001)
Ν	251888	30897	57020	251888	30897	57020
R-sq	0.916	0.939	0.907	0.915	0.938	0.906
Conrol	rta, Dodd_(i,j)					
Exporter-hscode-year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Importer-hscode-year fixed efects	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-importer-hscode fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
11	-1.094e+07	-3129857.121	-5818045.191	-1.095e+07	-3138986.291	-5826532.571

Table 6. Relationship with Conflicts (The boundary point of time is the end of 2012)

- Values in the parentheses are standard errors clustered by exporter, importer, hscode.

- ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
	All	Raw	Tantalum	Tungsten
DRC_CPI	-0.036**	-0.036***	-0.055***	-0.027
	(0.015)	(0.012)	(0.007)	(0.039)
DRC_CPI_Dodd	0.026***	0.026	0.034***	0.013***
	(0.005)	(0.016)	(0.002)	(0.004)
Neighbor_CPI	0.002	0.002	-0.002	0.026***
	(0.019)	(0.019)	(0.006)	(0.009)
Neighbor_CPI_Dodd	0.012	0.012	0.002*	0.039***
	(0.009)	(0.013)	(0.001)	(0.002)
N	189630	23199	42579	147051
R-sq	0.925	0.941	0.919	0.939
Control	rta	rta	rta	rta
Exporter-hscode-year fixed effects	Yes	Yes	Yes	Yes
Importer-hscode-year fixed efects	Yes	Yes	Yes	Yes
Exporter-importer-hscode fixed effects	Yes	Yes	Yes	Yes
11	-8684205.759	-2554258.306	-4357313.218	-4321659.507

Table 7. Corruption in Resources Trade

- Values in the parentheses are standard errors clustered by exporter, importer, hscode.

- ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels, respectively.







2(a). Before-enforcement (2000 to 2010). 2(b). After-enforcement (2011 to 2019). Figure 2. Trade Networks (Average indegree and outdegree) of Tin



3(a). Before-enforcement (2000 to 2010).3(b). After-enforcement (2011 to 2019).Figure 3. Trade Networks (Average indegree and outdegree) of Tungsten



Figure 4. The numbers of desths caused by conflicts



Figure 5(a). Clusters of trade networks for tungsten ores and concentrates in 2007



Figure 5(b). Clusters of trade networks for tungsten ores and concentrates in 2014

Figure 5. Changes in clusters of trade networks for tungsten ores and concentrates.