Sustainable Relationships*

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Abstract

The environmental impact of agricultural Global Value Chains (GVCs) has become an increasing source of concern. These chains are dominated by large international buyers whose sourcing strategies, shaped by managerial decisions, vary considerably. This paper investigates how such differences in sourcing organization relate to environmental outcomes within agricultural GVCs. Drawing on detailed transaction-level data from Côte d'Ivoire's cocoa GVC, we find that buyers adopting more relational sourcing strategies are associated with lower levels of deforestation. This effect is mediated by managers' educational backgrounds which influence the sourcing strategies their firms adopt and, ultimately, deforestation. Overall, the findings highlight the central role of buyer–supplier relationships in either promoting or constraining environmental sustainability in agricultural GVCs.

Keywords: Global Value Chains, Relational Contracts, Managers, Deforestation, Cocoa

JEL classifications: D22; D23; L14; L22; Q56

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1 Introduction

Global Value Chains (GVCs) have become a central feature of today's global economy, linking producers, suppliers, and consumers across countries. While GVCs are often seen as a pathway to economic development for low- and middle-income countries, their environmental consequences are increasingly a cause for concern (World Bank, 2020). Agricultural GVCs in particular are estimated to drive about 26% of forest loss in tropical and subtropical regions, which is one of the primary drivers of global environmental degradation (Pendrill et al., 2019; Berman et al., 2023). In response, the importance of environmental requirements within GVCs has grown substantially in recent years. New regulatory frameworks such as the European Union Deforestation Regulation (EUDR), the EU Supply Chain Directive, and the US Supply Chain Due Diligence Act exemplify the mounting pressure on firms to ensure that sourcing and production practices are sustainable.

A critical yet often overlooked dimension of environmental sustainability in GVCs concerns the role of large international buyers.[1] Recent research highlights substantial heterogeneity in how these buyers organize their sourcing strategies. Some rely extensively on relational sourcing, building long-term relationships with a stable set of core suppliers (Cajal-Grossi et al., 2023; Heise et al., 2024). The design of these sourcing strategies is often shaped by managerial decision-making (Helper and Henderson, 2014; Intintoli et al., 2017; Troya-Martinez and Wren-Lewis, 2023). In business schools, for instance, managers are explicitly trained to favor relational sourcing when dealing with strategic or risk-sensitive inputs, such as agricultural commodities from developing countries (Kraljic, 1983; Chopra and Sodhi, 2004; Chopra and Meindl, 2019).[2] Because compliance with environmental standards is inherently difficult to monitor and codify in formal contracts, relational buyers led by managers with business training may be better positioned to uphold environmental standards in their supply chains (Macchiavello, 2022; Boudreau et al., 2023).[3]

This paper investigates whether, and to what extent, buyers' sourcing strategies influence environmental sustainable practices in agricultural GVCs. Answering this question poses two key challenges. First, it requires granular transaction-level data that can trace flows from producers to international buyers-data that are typically scarce in agricultural value chains. Second, it demands an understanding of the largely unobservable mechanisms through which buyers design their sourcing practices. To address these challenges, we draw on rich, unique data from Côte d'Ivoire's cocoa GVC, combining detailed international trade records with granular information on deforestation, intra-national flows, along with information on managers' educational backgrounds. This allows us to assess and trace buyers' sourcing strategies, their managers, and their associated deforestation impacts.[4]

[1]Large firms dominate many sectors of the global economy (Autor et al., 2020; De Loecker et al., 2020). For example, the top one percent of importers account for 83.5% of U.S. imports (Bernard et al., 2018).

[2]The Kraljic matrix, for instance, classifies inputs by supply risk and profit impact to guide sourcing strategy. Non-critical items, with low value and low risk, are suited to spot purchasing. Strategic items, both high in value and risk, call for long-term partnerships and collaborative contracts (Kraljic, 1983).

[3]Relational contracts between firms play a crucial role in upholding agreements, as a "lack of trust and commitment" is frequently cited as the main reason why firms' relationships fail (Troya-Martinez and Wren-Lewis, 2023).

[4]While our main focus is deforestation in Côte d'Ivoire we leverage custom data also from other producing

This setting offers an ideal context for analyzing how differences in buyers' sourcing approaches shape environmental sustainability outcomes, beyond just data availability. Cocoa generates over US$100 billion annually, with chocolate products enjoyed by billions of consumers worldwide. For producing countries, cocoa is a vital export crop, often accounting for more than 20% of total export revenues, and it provides an important source of rural employment (Basic and FAO, 2020). Yet, cocoa production is a significant driver of deforestation: globally, cocoa is the fourth largest driver of commodity-related deforestation, following beef, soy, and palm oil (Global Forest Watch, 2024). In Côte d'Ivoire, the world's largest cocoa producer, approximately 2.4 million hectares of forest were converted to cocoa plantations between 2000 and 2019, representing about 45% of the country's total deforestation and forest degradation during that period (Renier et al., 2023). At the same time, the cocoa sector is characterized by a buyer-driven GVC, where a few multinational firms dominate cocoa sourcing and primary processing (Squicciarini and Swinnen, 2016; Oxfam, 2024). It is therefore an industry that is both economically critical and environmentally sensitive.

Our results show that international buyers that rely more heavily on relational sourcing are associated with lower deforestation impacts. Specifically, a one-standard deviation increase in the relationality metric corresponds to a 6-9% reduction in deforestation. For this result, we exploit granular seller-destination-year variation, i.e., comparing different buyers importing from the same seller, to the same destination in the same year. These results are robust to alternative definitions of the sourcing metric, sample restrictions, and controls for departments' and buyers' characteristics, as well as to different combinations of seller, destination, and year fixed effects.

We further analyze how managers' educational backgrounds may account for this finding. Building on evidence that managerial education shapes firms' organizational practices and governance structures (Acemoglu et al., 2022), we test whether managers with business-related training are more likely to adopt relational sourcing strategies. Business education often emphasizes the strategic value of long-term partnerships, especially when inputs are high-value or risk-sensitive. We find suggestive evidence that managers with a business education rely more on relational sourcing. As a result, their firms are less likely to be associated with deforestation in the cocoa sector.

Related Literature This paper builds on three main strands of literature. First, it relates to the extensive body of work on trade and the environment, which highlights how international trade and GVCs affect environmental outcomes such as deforestation, carbon emissions, and biodiversity loss (Lambin et al., 2018; Abman and Lundberg, 2020; Farrokhi and Lashkaripour, 2021; Hsiao, 2021; Dominguez-Iino, 2021; Carreira et al., 2024; Gianinazzi et al., 2024; Gollin and Wolfersberger, 2025).[5] While this literature has established that trade can be a significant driver of environmental degradation, relatively less attention has been paid to how buyers' sourcing strategies may mediate these impacts. This paper

countries, namely Ghana and Ecuador, to identify the sourcing strategies adopted by the international buyers globally. These three countries together account for roughly 70% of global cocoa production (see Section 2).

[5]See Copeland et al. (2022) for an extensive review.

contributes to this gap by emphasizing the role of sourcing strategies as a critical channel through which trade affects environmental sustainability.

Second, our work connects to research on responsible sourcing (Koenig and Poncet, 2019, 2022; Herkenhoff and Krautheim, 2022; Boudreau, 2024; Alfaro-Ureña et al., 2025). Recent studies have shown that when buyers establish long-term, trust-based relationships with suppliers, often referred to as relational contracting, they can create incentives for improved social conditions (Macchiavello and Morjaria, 2021; Boudreau et al., 2023). By linking buyers' relational sourcing practices to sustainability outcomes in the cocoa sector, this paper provides evidence on the environmental implications of buyer–supplier relational contracts.

Third, this study contributes to a growing literature on management and relationships, which examines how managerial background, ideology and skills shape a firm's organizational structures (Acemoglu et al., 2022; Troya-Martinez and Wren-Lewis, 2023; Kempf et al., 2025). Our paper suggests that managers' education influences the adoption of sourcing strategies and, consequently, their upstream impacts on sustainability.

The rest of the paper is organized as follows. Section 2 provides a background of the cocoa supply chain and describes the data. Section 3 introduces the key measures together with some key stylized facts. Section 4 presents the empirical strategy and the results. Finally, Section 5 concludes.

2 Background and Data

2.1 Background

Global sales of chocolate confectionery products were valued at about US$110 billion in 2019, a 33% increase since 2008/09. Côte d'Ivoire is the world's largest cocoa producer, with around one million smallholders cultivating plots of 2–5 hectares and collectively producing over 2 million tonnes of cocoa beans each year, about 40% of global supply (Basic and FAO, 2020). Despite these modest farm sizes, cocoa expansion has been a major driver of deforestation. Farmers frequently clear forests and bushland to increase production, rather than converting existing cropland. A 2018 survey by Bymolt et al. (2018) found that 35% of Ivorian households expanded their cocoa area in the preceding five years, and two-thirds did so by clearing natural vegetation. From 2003 to 2017, an estimated 1.65 million hectares of tropical moist forest were converted to cocoa plantations, representing 45% of Côte d'Ivoire's total forest loss during this period. This corresponds to an average of 110,000 hectares lost annually, nearly the size of New York City (Guye, 2024).

The cocoa production process begins on smallholder farms, where ripe pods are harvested manually, and beans are fermented and dried by farmers before entering local markets. In Côte d'Ivoire, farmers sell to local aggregators, cooperatives or intra-national traders, which then channel the beans to international buyers supplying the global market. Farmers make the physical decision about where to plant, and the expansion of farms into forested areas remains the most immediate driver of deforestation. Local aggregators can influence these dynamics by deciding whether to purchase cocoa from farmers in forest-risk areas. However, it is the international buyer, who individually buys large volumes, that wield the greatest leverage. They can require traceable and certified cocoa, finance sustainability and traceability programs, and determine whether to pay the price premiums that make sustainable production viable. Their procurement choices, therefore, ultimately shape the incentives that guide farmers' land-use decisions (World Cocoa Foundation, 2023).[6]

2.2 Data

Our empirical analysis integrates detailed international trade records with a high-resolution map of deforestation for cocoa and domestic supply chain data, along with information on buyers' management structures, to trace sourcing strategies and their associated deforestation in the cocoa sector.

We use customs data from Côte d'Ivoire, Ecuador, and Ghana covering the period 2018 to 2023. These three countries together account for roughly 70% of global cocoa production. For each transaction, the data include the volume in kilograms (kg) and the cost insurance and freight (CIF) value (in nominal US dollars), destination, origin, and product type (captured using 6-digit HS codes within heading 18, which corresponds to cocoa and its preparations).[7] Each record identifies the international buyer and the seller by name and address.

For Côte d'Ivoire, we further leverage detailed production and supply chain data from Trase for the years 2019–2022, which provide information on cocoa production areas at the department level, cocoa-driven deforestation, the locations of farmer cooperatives, and publicly disclosed cooperative–trader relationships. This allows us to map sourcing flows from the department of production to international buyers.

The final dataset includes approximately 140,000 observations at the Department–Coop–Seller–Buyer–Destination–Year level.

To complement this, we collect biographical information on the cocoa buyers' managers from online sources such as LinkedIn, Bloomberg, and company websites. For each manager, we record details about their post-secondary education, including the institution attended, degree earned, and major field of study.

3 Measurement and Facts

3.1 Measurement

Relationality To capture buyers' approaches to sourcing, we follow the methodology proposed by Cajal-Grossi et al. (2023) and Heise et al. (2024). The key measure is relationality,

[6] Macchiavello and Miquel-Florensa (2019) document how a buyer's program in the Colombian coffee value chain serves as a key driver of upgrading and higher farmer incomes.

[7] The main exported cocoa product is cocoa beans, classified under HS Code 180100, which represent approximately 50% of the international trade transactions in our sample. Following the Trase methodology, all empirical results are expressed in bean-equivalent volumes and aggregated across relevant HS codes, excluding HS code 180200 which represents cocoa waste.

which exploits the idea that, conditional on total sourced volumes, more relational buyers concentrate procurement within a smaller network of sellers.[8] Formally, we define the buyer-level relationality metric as:

$$Relational_b = \sum_{jc} \left[\frac{PQ_{bjc}}{PQ_b} \times Relational_{bjc} \right] \quad \text{and} \quad Relational_{bjc} = -\frac{N^s_{bjc}}{N^i_{bjc}},$$

where N^i_{bjc} is the number of shipments in the buyer–product–origin combination, and N^s_{bjc} is the number of sellers in the buyer–product–origin combination. The (negative of the) ratio of sellers to shipments is aggregated at the level of the buyer by weighing each product-origin combination by their share in the buyer's imported values, denoted with PQ, in the data.

For our baseline, we construct the relationality measure using 2018 data on international buyers in Côte d'Ivoire, Ghana, and Ecuador, which together account for over 70% of global cocoa production. Relying on multiple origins rather than a single country offers two main advantages. First, it allows us to capture buyers' global sourcing strategies rather than strategies that might reflect country-specific institutions, regulations, or characteristics. Second, by observing buyers across countries, we gain greater variation which improves the precision and external validity of our relationality metric.[9]

Deforestation To measure the environmental footprint associated with buyers, we construct the Cocoa Deforestation Exposure (CDE) of every buyer each year, expressed in hectares of cocoa traded. We construct the CDE using the SEI-PCS model developed by Trase in the context of cocoa in Côte d'Ivoire (Renier et al., 2023; Trase, 2024).

This model uses remote sensing data to calculate the area of tropical moist forest replaced by cocoa in every department of Côte d'Ivoire during a 15-year period. Cocoa deforestation is then allocated to the volumes handled annually by each buyer. The allocation is based on trade links between farmer cooperatives and buyers, either identified in the customs data (for exporting cooperatives) or via supply chain disclosures made by major sellers. Using these identified sourcing links, their estimated sizes, and the locations of cooperatives, we estimate annually the volumes sourced from cooperatives in each department by each buyer. These volumes represent 85% of Ivorian cocoa exports and more than 90% of total transactions in our sample. For each buyer, the CDE sums up the product of these volumes by cocoa deforestation in departments, and the product of the remaining volume (that cannot be linked to a specific department) by a country-year average of cocoa deforestation (see Appendix A.3 for detailed explanations).[10]

[8]Therefore, buyers range from "spot" buyers, who spread short-term orders among many low-bidding sellers and absorb performance risks, to "relational" buyers, who concentrate orders with a few trusted sellers to build long-term partnerships (Taylor and Wiggins, 1997).

[9]We only use 2018 data as the baseline, as our deforestation measure begins in 2019. As a robustness check we show that our results are robust to the use of a measure calculated using both 2018 and 2019 data.

[10]In Section 4.1 we show that our results are robust to the exclusion of transactions that cannot be directly linked to a department.

Business Manager Following Acemoglu et al. (2022), we classify CEOs holding a degree from a business school as "business managers". We define business schools as institutions with "Business" in their name, with a few notable exceptions (e.g., Wharton, INSEAD, HEC). We then match buyers in our main sample to these CEOs, restricting attention to those active in 2018 to align with our baseline relationality measures. In total, we match 85 buyers to their CEOs, of whom 30% hold a business degree.[11]

We focus on CEOs with a business degree for two key reasons. First, CEOs have considerable autonomy in operational matters, and their vision and management style are important determinants of firm strategies (Bertrand and Schoar, 2003; Acemoglu et al., 2022). Second, business schools explicitly train future managers to distinguish between when to rely on spot transactions and when to develop long-term supplier relationships, favoring the latter when sourcing strategic, high-value, or risk-sensitive inputs, such as cocoa beans from Côte d'Ivoire. These topics are standard in MBA and executive education curricula, including courses such as Operations Management and Supply Chain Strategy and Practice (Kraljic, 1983; Chopra and Sodhi, 2004; Chopra and Meindl, 2019). As a matter of fact, Heise et al. (2025) show that agriculture is among the US import sectors most engaged in relational sourcing.

Table A1 summarizes the main descriptive statistics relevant to our analysis.

3.2 Facts

In this section, we document three stylized facts on the role of large buyers and their managers in the cocoa sector. Together they suggest the existence of substantial heterogeneity in both their sourcing strategies and exposure to deforestation.

We find (i) that large buyers have different approaches to sourcing, (ii) a significant dispersion in cocoa deforestation exposure across buyers, and (iii) managers have different educational backgrounds.

Fact I: Large buyers have different approaches to sourcing

Table 1 examines the 10 largest among the more than 1,100 buyers of cocoa across the countries in our sample that are active in Côte d'Ivoire. The table presents buyers in descending order based on their in-sample market shares. Cargill, Barry Callebaut and Olam are the largest buyers with market shares of 16%, 15%, and 14% respectively, and the top 10 buyers altogether account for 80% of the global market share.

[11] In an alternative definition, we classify CEOs whose major is in a business-related discipline as "business managers."

Table 1: Top Buyers and Sourcing Strategies

	(1) Mkt Share	(2) Num Origins	(3) Num Destinations	(4) Relationality	(5) Relationality Rank
CARGILL	0.16	1.60	12.25	1.77	8
BARRY CALLEBAUT	0.15	1.74	32.05	1.75	14
OLAM	0.14	1.75	31.38	1.77	4
ECOM	0.11	1.78	22.80	1.74	16
TOUTON	0.09	1.40	24.78	1.80	3
SUCDEN	0.08	1.68	21.78	1.76	13
ACT	0.03	1.07	14.01	1.74	19
COMOD TRADING	0.02	1.00	7.53	1.77	10
ETC GROUP	0.02	1.42	13.65	1.64	37
COCOASOURCE	0.01	1.28	10.91	1.43	67
Top 10	0.81	1.47	19.11	1.72	19
Top 20	0.91	1.35	13.71	1.59	42

Notes: The table reports the top 10 buyers across the countries in our sample that are active in Côte d'Ivoire. Top buyers are ranked according to the average (global) market share. In columns (2)-(4) we report average values. Relationality is computed using 2018 data only.

Even within this relatively small group of large buyers, sourcing approaches vary substantially. Under the heading *Relationality Rank*, buyers are ordered according to their degree of relationality, with the top rank corresponding to the most relational buyer. This ranking aligns closely with qualitative evidence from industry accounts. For example, Cargill, ranked eight, is a large buyer known for its relational approach to sourcing, while Ecom, known for a spot sourcing strategy, is ranked lower. In 2013 Cargill began to change how it approached the entire production cycle of cocoa procurement, establishing a multi-year, long-term, purchasing program that directly ties progress in several sustainability measures with pricing and third-party verification of results (Cargill, 2016). ECOM instead either sources cocoa beans through its local subsidiaries or via suppliers, but it does not manage the transport of cocoa beans in the supply chain (IFC, 2024).[12]

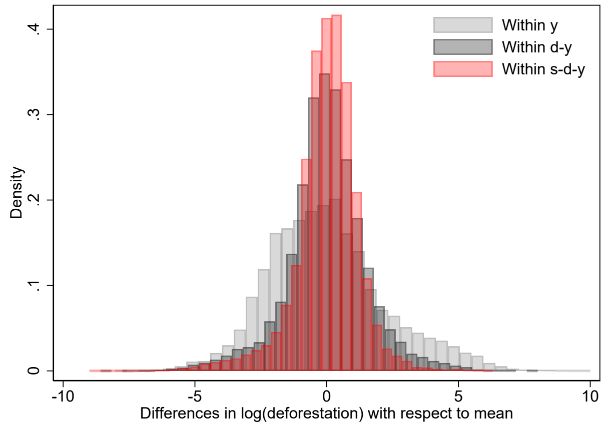
Fact II: Significant dispersion in deforestation across buyers

We then document a significant dispersion in cocoa deforestation in hectares (ha) across buyers (Figure 1). This is true controlling year fixed effects, destination $\times$ year fixed effects to compare similar destination markets (i.e., controlling for size of the market) and even for seller $\times$ destination $\times$ year fixed effects, i.e., comparing different buyers importing from the same seller, to the same destination in the same year. This suggests buyers have specific characteristics that considerably affects deforestation exposure.

Anecdotal evidence illustrates this point when examining imports from the same supplier, ETC Group, into the same country, the Netherlands, in the same year, 2019, by Cargill and

[12] Moreover, to better understand what drives differences in sourcing strategies across firms, we decompose our relational metric into its main sources of variation. Replicating Cajal-Grossi et al. (2023) and Cajal-Grossi et al. (2023), we perform a variance decomposition to compare the importance of buyer-specific factors with product, origin, or destination effects. This is done by measuring the loss of fit when removing fixed effects from more saturated specifications. Table A2 shows that buyer-specific effects explain the largest share of the variation in sourcing strategies, i.e., 53% in our most detailed specification, compared to 3% for product-country and 31% for product-destination effects. These findings suggest that buyer-level capabilities, rather than market conditions alone, play a central role in shaping sourcing behavior.

Figure 1: Cocoa deforestation exposure dispersion



Notes: This figure shows the residuals from three regressions. In each case, the dependent variable is the difference in log cocoa deforestation exposure in hectares (ha) relative to the average log cocoa deforestation exposure in hectares (ha) within an year and, a destination-year, and a supplier-destination-year respectively. The regressions include the same set of fixed effects.

ECOM. Figures A2 and A3 show that, within this market, the two buyers exhibit different exposure across departments.

Fact III: Managers have different educational backgrounds

Finally, Table 2 summarizes the diverse educational backgrounds of CEOs at the top 10 buying firms. It lists each CEO's name, appointment date, alma mater, and whether they are classified as a business manager according to our definition in Section 3.[13]

Table 2: Top Buyers and Business Managers

	(1) CEO Name	(2) CEO since	(3) University	(4) Business Manager
CARGILL	David MacLennan	2013	Chicago Booth School of Business	1
BARRY CALLEBAUT	Antoine de Saint Affrique	2015	ESSEC Business School	1
OLAM	Gerard Manley	2015	City St George's University of London	0
ECOM	Nicolas de Wasseige	2014	The University of Manchester	0
TOUTON	Eric Guimberteau	2014	Universite de Bourdeaux I	0
SUCDEN	Auke Vlas	2016	Erasmus Universiteit Rotterdam	0
ACT	Marinela Stan	2018		
COMOD TRADING				
ETC GROUP	Birju Patel	1986	LSE	0
COCOASOURCE	Hubert Hoondert		Regent's University London	

Notes: The table reports the top 10 buyers in Côte d'Ivoire and their CEOs at the time our baseline relationality metric is computed, namely 2018. We classify CEOs holding a degree from a business school as "business managers." We define business schools as institutions with "Business", or "Management" in their name, with a few notable exceptions (e.g., Wharton, INSEAD, HEC).

Consistent with the earlier anecdotal evidence, where Cargill is characterized as a relational buyer and Ecom as a spot buyer, we find that Cargill's CEO, David MacLennan, holds a degree from Chicago Booth and is thus classified as a business manager. In contrast, Ecom's CEO, Nicolas de Wasseige, graduated from the University of Manchester and is not

[13]We also collect additional details such as their field of study and LinkedIn profile.

classified as a business manager. This evidence is consistent with the emphasis in business school curricula on fostering relational contracts for these inputs.

4 Empirical Strategy and Results

We analyze the relationship between sourcing strategies and deforestation, as follows:

$$Deforestation_{bsdt} = \beta_0 + \beta_1 Relational_b + \mathbf{X}_{bsdt} + \mathbf{FE} + \epsilon_{bsdt}$$

where $Deforestation_{bsdt}$ is the log of cocoa deforestation exposure (ha) by a buyer b in a year y to a destination d from a supplier s.[14] The vector $\mathbf{X}$ includes a set of time-varying buyer-supplier characteristics, including the (log of) export volumes, (log of) price, and (log of) land use exposure (ha), while **FE** includes fixed effects that absorb seller-destination-year variation, thereby accounting for all time invariant and varying observed and unobserved characteristics of both the seller and the destination market, as well as the overall trends in economic activity and common shocks. These fixed effects allow us to compare differences across buyers importing from the same seller to the same destination in that year. The regressor of interest, $Relational_b$, is our baseline metric of buyers' sourcing defined in Section 3, in 2018 and it is standardized.

Table 3 reports the results. Column (1) shows that a standard deviation increase in the sourcing metric (i.e., a greater reliance on relational sourcing by the buyer) is associated with 6% lower deforestation exposure. Columns (2) and (3) sequentially add fixed effects controlling for unobserved specific seller-cost and demand shocks, separately, and altogether, respectively. Across all specifications, the estimated coefficient ranges from 6.3% to 9.6%.

Table 3: Deforestation and Relationality

	Deforestation		
	(1)	(2)	(3)
$Relational_b$	-0.063**	-0.071***	-0.096***
	(0.025)	(0.024)	(0.025)
Obs.	139,440	139,440	139,440
FEs	s, d, y	sy, dy	sdy
Controls	✓	✓	✓
R^2	0.96	0.96	0.96
Mean DV	3.23	3.23	3.23

Notes: The table shows regressions of the log of cocoa deforestation exposure in hectares (ha) by a buyer b in a year y to a destination d from a seller s. The main regressor in all cases is the baseline, buyer-specific metric of relational sourcing and it is standardized. Controls include (log of) export volumes, (log of) price, and (log of) land use exposure ha. Standard errors clustered at buyer-level in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

[14] In fact, the unit of analysis is more granular than a combination $bsdt$, as we observe Department–Coop–Seller–Buyer–Destination–Year level. Following Renier et al. (2023), we assume that cooperatives source from the department they are located in.

4.1 Robustness Checks

In this section, we first validate our empirical strategy and then demonstrate that our findings are robust across a series of robustness checks. Across all specifications, the estimated coefficients remain largely stable.

A potential concern for our identification strategy is that unobserved buyer- and location-specific characteristics may simultaneously affect both relationality and deforestation. On the buyer side, a relevant factor could be the location of corporate headquarters in Europe, where firms operate under stronger regulatory and reputational pressures. On the local side, we further include nighttime light intensity, farming population and mining activities at the departmental level.[15]. Table A3 shows that, across all specifications, the results remain largely unchanged providing additional support for our identification strategy.

More formally, to assess the extent of selection on unobservables, we apply the test proposed by Altonji et al. (2005) and Oster (2019). This test estimates the relative importance of unobservables, captured by the parameter δ. When $\delta = 1$, the selection on unobservables is assumed to be as important as selection on observables. As shown in Table A4, our baseline estimate (Table 3, column 3) remains largely stable as δ increases from 0.1 to 1 (columns 2–7). In column 8, we report a value of -2.48, indicating that unobservables would need to be more than twice as influential as observables, and in the opposite direction, to nullify the effect. This appears unlikely given the extensive set of fixed effects included in our specification.

Another potential threat to our identification strategy could be reverse causality. It is important to recall that our measure of relationality is constructed using pre-deforestation data for Côte d'Ivoire, Ghana, and Ecuador (see Section 3). This design ensures that the metric captures buyers' global sourcing strategies as of 2018, rather than reflecting subsequent, country-specific decisions.

In Table A5 we explore alternative relationality metrics, namely a relationality standardized by origin country $Relationality_c$ which accounts for differences in sourcing across producing countries, a dummy based on the 95th percentile of the relationality $Relationality_D$, and a relationality computed on both 2018 and 2019 $Relationality_{18-19}$.

In Table A6 we use different samples. We first exclude all those transactions for which the domestic sourcing linkage is indirect or the department of origin is unknown, thereby restricting to the subset of transactions with fully identified department-level origins (Column (1)). In Column (2) we exclude all potential vertical integration (VI) cases, that is when the seller's and buyer's name coincide. In Column (3) we exclusively consider exports to the top destinations, namely The Netherlands (NED), Germany (DEU), and Belgium (BEL), while in Column (4) all other countries. Finally, in Column (5) we exclude 2020 to avoid including the first wave of Covid-19 in our sample.

[15] Nighttime light data in 2018 are from Li et al. (2020), and farming population estimates for 2019–2022 are from Trase. For mining, we use the U.S. Geological Survey (USGS) dataset on mining in Africa (Padilla et al., 2021), which reports the location and type of mining operations as of 2021. Figure A4 illustrates the spatial distribution of mining activities. From this dataset, we construct an indicator variable that take value 1 in the presence of (i) a mining facility, (ii) an exploration concession, (iii) a mineral deposit.

Finally, in Table A7 we show the results using an alternative clustering of the standard-errors, i.e., at the buyer-year-level.

4.2 The Role of Managers

In this section, we explore the role of the educational background of managers in linking sourcing strategies to deforestation. The idea is that managerial training may shape how firms interact with suppliers. Specifically, we hypothesize that managers with business-related degrees are more likely to value stable, long-term relationships with cocoa sellers, thereby providing stronger incentives for local producers to adopt sustainable practices and deter land degradation.

We first document a positive correlation between the educational background of CEOs and firms' relational sourcing strategies in the cocoa sector. Table A8 shows that firms led by CEOs with a business degree tend to exhibit higher levels of relationality. This association holds across alternative measures of relationality but is not statistically significant, likely due to the small sample size.[16] This descriptive evidence is consistent with the idea that business education emphasizes the strategic value of long-term partnerships, particularly in contexts where inputs are high-value or risk-sensitive, such as cocoa sourced from developing countries. Notably, in the ready-made garment sector, where production is time-sensitive due to rapid fashion cycles and inputs are relatively standardized, the pattern reverses: firms managed by business-trained CEOs are negatively correlated with relational sourcing (Table A10).[17]

We next examine the underlying mechanism by testing whether the effect of relationality on deforestation is heterogeneous across buyers depending on their CEO's background. As shown in Table 4, the effect is indeed stronger among buyers led by CEOs with a business degree. The differences in the effects of relationality on deforestation between firms headed by business managers and firms headed by non-business managers are significant at the 5% level.[18]

[16] Similar results obtain when defining business managers based on their major (Table A9).

[17] Customs data used to compute the relationality metric are from Cajal-Grossi et al. (2023).

[18] These results are robust to the use of alternative definitions of relationality (Table A11) and managers' background (Table A12).

Table 4: Deforestation, Relationality and CEO Background

	Deforestation		
	(1)	(2)	(3)
$Relational_b \times Non-Business\ Manager$	-0.039	-0.047*	-0.070***
	(0.027)	(0.024)	(0.024)
$Relational_b \times Business\ Manager$	-0.078***	-0.084***	-0.100***
	(0.020)	(0.018)	(0.018)
Obs.	135,106	135,106	135,106
FEs	s, d, y	sy, dy	sdy
Controls	✓	✓	✓
R^2	0.96	0.96	0.96
Mean DV	3.23	3.23	3.23
F-test p value	0.006	0.006	0.027

Notes: The table shows regressions of the log of cocoa deforestation exposure in hectare (ha) by a buyer b in a year y to a destination d from a seller s. The main regressor in all cases is the baseline, buyer-specific metric of relational sourcing and it is standardized. Business Manager is a dummy that takes value 1 if the CEO has a business background. Controls include (log of) export volumes, (log of) price, and (log of) land use exposure ha. We report the p-value for the F-test testing the difference between the coefficients at the bottom of the table. Standard errors clustered at buyer-level in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Taken together, these results suggest that managerial education may mediate how relational sourcing influences environmental outcomes. In supply chains highly exposed to environmental risks, managers with business training may, for instance, design procurement systems that reward supplier continuity, allocate resources to sustainability functions, or embed environmental criteria within sourcing contracts. Such organizational choices can, in turn, enhance the credibility of sustainability commitments and strengthen suppliers' incentives to adopt practices that mitigate deforestation risk.

5 Conclusions

Agricultural GVCs are central to shaping environmental outcomes worldwide. International trade and consumption of agricultural commodities account for roughly one-quarter of forest loss in tropical and subtropical regions. These markets are dominated by a few large international buyers, which vary considerably in their sourcing strategies, particularly in the extent to which they rely on long-term, relational contracts.

In this paper, we assemble a novel, transaction-level dataset that traces deforestation embedded in the cocoa supply chain. Our analysis shows that buyers relying more heavily on relational sourcing strategies, concentrating procurement among a smaller set of core sellers, are systematically associated with lower exposure to deforestation. We also find that CEOs with a business education background are more likely to pursue relational sourcing strategies, underscoring the role of managerial training and incentives in shaping supply chain organization and its environmental impacts

These findings are likely to extend beyond the cocoa sector, as relational contracts are pervasive across similar commodities, such as coffee, and the broader agricultural sector (Boudreau et al., 2023; Heise et al., 2025).

Taken together, these results highlight how the structure of buyer–supplier relationships can either advance or undermine sustainability goals in agricultural GVCs. From a policy perspective, this implies that interventions must account for the organization of markets rather than focus exclusively on domestic actors. Targeting only producers risks overlooking the responsibility of global lead firms, whose sourcing decisions largely determine the environmental footprint of agricultural trade. From the perspective of developing countries, attracting foreign buyers that will invest in relationships along their supply chains may be a promising direction for environmental objectives and, more broadly, for the sustainability and resilience of supply chains (Cajal-Grossi et al., 2023).

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A Online Appendix

A.1 Tables

Table A1: Descriptive Statistics

	Mean	Median	SD	Min	Max
Sellers	67.965	69.000	1.937	63.000	71.000
Buyers	93.064	95.000	6.350	64.000	101.000
Destinations	43.712	44.000	0.476	42.000	44.000
Deforestation	144.192	11.102	957.583	0.000	72770.072
Relational$_b$	1.733	1.755	0.163	-0.938	1.804

Notes: The Table reports some key statistics of the data used. The country of origin is Côte d'Ivoire and covers the years 2019-2022. The table shows the number of unique sellers, buyers, and destinations per year. It also reports the average deforestation in hectare (ha) and the baseline measure of relationality.

Table A2: Sources of Variability in Relationality

Decomposition based on loss of fit (% of R^2)					
Fixed effects set:	I^1	I^2	I^3	I^3	I^4
Destination	40.19				
Buyer		76.39	75.72	80.99	53.11
Product	17.04	3.03			
Country	4.87	1.32			
Product-country			4.85	15.67	2.78
Product-destination					31.15
Sample		All		Multi-country	
Observations	1,137	678	678	269	190

Notes: Each entry reflects the loss of fit resulting from removing the fixed effects in the rows from a linear projection of $Relational_{bjc}$ on the set of fixed effects in each I specification (columns). The specifications are as follows: $I^1 = \{destination, product, country\}$, $I^2 = \{buyer, product, country\}$ and $I^3 = \{buyer, product - country\}$ and $I^4 = \{buyer, product - country, product - destination\}$. The loss of fit is computed as the share over the fit in the full model: $(R_I^2 - R_{I-i}^2)/R_I^2$. The first three columns of the table use all buyer–product–country triplets available in the global data. The last two columns restrict attention only to buyers present in two or more countries.

Table A3: Deforestation and Relationality (Buyer and Department Controls)

	Deforestation				
	(1)	(2)	(3)	(4)	(5)
$Relational_b$	-0.089***	-0.106***	-0.108***	-0.111***	-0.092***
	(0.020)	(0.024)	(0.025)	(0.025)	(0.023)
Obs.	124,305	124,305	124,305	124,305	124,305
FEs	sdy	sdy	sdy	sdy	sdy
Controls	✓	✓	✓	✓	✓
Nighttime Lights	✓				✓
Log Farmer Pop		✓			✓
Mining			✓		✓
HQ EU				✓	✓
R^2	0.95	0.96	0.95	0.95	0.97
Mean DV	2.96	2.96	2.96	2.96	2.96

Notes: The table shows regressions of the log of cocoa deforestation exposure in hectare (ha) by a buyer b in a year y to a destination d from a seller s. The main regressor in all cases is the baseline, buyer-specific metric of relational sourcing and it is standardized. Controls include (log of) export volumes, (log of) price, and (log of) land use exposure ha. We also include as a control mining activity at the departmental level in 2021, as well as (log) nighttime light activity at the departmental level in 2018 and (log) farmer population. HQ EU is a dummy equal to 1 if the buyer has headquarters in an European country. Standard errors clustered at buyer-level in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table A4: Test for Selection on Unobservables

	Main result	$\delta = 0.1$	$\delta = 0.2$	$\delta = 0.4$	$\delta = 0.6$	$\delta = 0.8$	$\delta = 1$	δ for $\beta = 0$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Relational_b$	-0.096	-0.100	-0.104	-0.113	-0.122	-0.131	-0.140	-2.48

Notes: In this table, we employ the Oster (2019) approach to test the stability of our estimates with respect to unobservable confounding factors. The coefficient δ is the relative degree of selection on observed and unobserved variables.

Table A5: Deforestation and Relationality (Relationality Robustness)

	Deforestation		
	(1)	(2)	(3)
Relational	-0.092***	-0.074***	-0.160***
	(0.024)	(0.026)	(0.041)
Obs.	139,440	139,440	139,440
FEs	sdy	sdy	sdy
Controls	✓	✓	✓
Var	Relational_c	Relational_d	$\text{Relational}_{b,18-19}$
R^2	0.96	0.96	0.96
Mean DV	3.23	3.23	3.23

Notes: The table shows regressions of the log of cocoa deforestation exposure in hectare (ha) by a buyer b in a year y to a destination d from a seller s. *Relational c* is a relationality standardized by origin country, *Relational D* is a dummy based on the 95th percentile of the relationality, and *Relational 18-19* is a relationality computed on both 2018 and 2019. Controls include (log of) export volumes, (log of) price, and (log of) land use exposure ha. Standard errors clustered at buyer-level in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table A6: Deforestation and Relationality (Heterogeneity)

	Deforestation				
	(1)	(2)	(3)	(4)	(5)
$Relational_b$	-0.088**	-0.086***	-0.121***	-0.089***	-0.101***
	(0.040)	(0.023)	(0.036)	(0.026)	(0.024)
Obs.	127,259	101,828	51,678	87,762	92,712
FEs	sdy	sdy	sdy	sdy	sdy
Controls	✓	✓	✓	✓	✓
Sample	No Indirect/Unknonw	No VI	NED/DUE/BEL	No NED/DUE/BEL	No 2020
R^2	0.95	0.95	0.93	0.96	0.96
Mean DV	2.94	3.73	4.46	2.51	3.26

Notes: The table shows regressions of the log of cocoa deforestation exposure in hectare (ha) by a buyer b in a year y to a destination d from a seller s. The main regressor in all cases is the baseline, buyer-specific metric of relational sourcing and it is standardized. Controls include (log of) export volumes, (log of) price, and (log of) land use exposure ha. Standard errors clustered at buyer-level in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table A7: Deforestation and Relationality (Alternative Clustering)

	Deforestation		
	(1)	(2)	(3)
$Relational_b$	-0.063***	-0.071***	-0.096***
	(0.020)	(0.019)	(0.017)
Obs.	139,440	139,440	139,440
FEs	s, d, y	sy, dy	sdy
Controls	✓	✓	✓
R^2	0.96	0.96	0.96
Mean DV	3.23	3.23	3.23

Notes: The table shows regressions of the log of cocoa deforestation exposure in hectare (ha) by a buyer b in a year y to a destination d from a seller s. The main regressor in all cases is the baseline, buyer-specific metric of relational sourcing and it is standardized. Controls include (log of) export volumes, (log of) price, and (log of) land use exposure ha. Standard errors clustered at buyer-year-level in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table A8: Relationality and CEO University

	Relational			
	(1)	(2)	(3)	(4)
$Business\ Manager$	0.181	0.187	0.177	0.107
	(0.187)	(0.194)	(0.145)	(0.095)
Obs.	49	49	49	49
Var	Relational_b	Relational_c	Relational_d	$\text{Relational}_{b,18-19}$
R^2	0.02	0.02	0.03	0.03

Notes: The table shows regressions of the buyer-specific metric of relational sourcing on business managers' education. $Relational_b$ is the baseline, buyer-specific metric of relational sourcing and it is standardized, $Relational_c$ is a relationality metric standardized by origin country, $Relational_d$ is a dummy based on the 95th percentile of the relationality, and $Relational_{b,18-19}$ is a relationality computed on both 2018 and 2019. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table A9: Relationality and CEO Major

	Relational			
	(1)	(2)	(3)	(4)
$Business\ Manager$	0.179	0.186	0.320**	0.041
	(0.176)	(0.183)	(0.131)	(0.091)
Obs.	50	50	50	50
Var	Relational_b	Relational_c	Relational_d	$\text{Relational}_{b,18-19}$
R^2	0.02	0.02	0.11	0.00

Notes: The table shows regressions of the buyer-specific metric of relational sourcing on business managers' major. $Relational_b$ is the baseline, buyer-specific metric of relational sourcing and it is standardized, $Relational_c$ is a relationality metric standardized by origin country, $Relational_d$ is a dummy based on the 95th percentile of the relationality, and $Relational_{b,18-19}$ is a relationality computed on both 2018 and 2019. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table A10: Relationality and Business Manager (RMG)

	Relational			
	(1)	(2)	(3)	(4)
$Business\ Manager$	-0.269***	-0.375**	-0.111*	-0.112
	(0.083)	(0.151)	(0.066)	(0.114)
Obs.	97	97	77	77
Var	Relational_b	Relational_d	Relational_b	Relational_d
Education	University	University	Major	Major
R^2	0.10	0.06	0.04	0.01

Notes: The table shows regressions of the buyer-specific metric of relational sourcing on business managers' education. $Relational_b$ is the baseline, buyer-specific metric of relational sourcing and it is standardized and $Relational_d$ is a dummy based on the 95th percentile of the relationality. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

Table A11: Deforestation, Relationality and CEO Background (Relationality Robustness)

	Deforestation		
	(1)	(2)	(3)
$Relational_b \times Non-Business\ Manager$	-0.053*	-0.072***	-0.166***
	(0.029)	(0.026)	(0.043)
$Relational_b \times Business\ Manager$	-0.105***	-0.118***	-0.197***
	(0.019)	(0.023)	(0.037)
Obs.	135,106	135,106	135,106
FEs	sdy	sdy	sdy
Controls	✓	✓	✓
Var	Relational_c	Relational_d	$\text{Relational}_{b,18-19}$
R^2	0.96	0.96	0.96
Mean DV	3.23	3.23	3.23
F-test p value	0.026	0.050	0.026

Notes: The table shows regressions of the log of cocoa deforestation exposure in hectare (ha) by a buyer b in a year y to a destination d from a seller s. $Relational_c$ is a relationality metric standardized by origin country, $Relational_d$ is a dummy based on the 95th percentile of the relationality, and $Relational_{b,18-19}$ is a relationality computed on both 2018 and 2019. Business Manager is a dummy that takes value 1 if the CEO has a business background. Controls include (log of) export volumes, (log of) price, and (log of) land use exposure ha. We report the p-value for the F-test testing the difference between the coefficients at the bottom of the table. Standard errors clustered at buyer-year-level in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

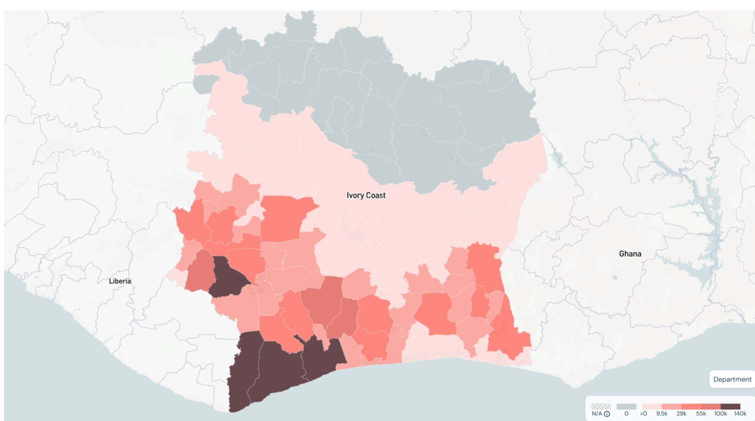
Table A12: Deforestation, Relationality and CEO Major

	Deforestation		
	(1)	(2)	(3)
$Relational_b \times Non-Business\ Manager$	0.032*	0.021	0.000
	(0.019)	(0.016)	(0.020)
$Relational_b \times Business\ Manager$	-0.042**	-0.052***	-0.071***
	(0.021)	(0.017)	(0.016)
Obs.	129,616	129,616	129,616
FEs	s, d, y	sy, dy	sdy
Controls	✓	✓	✓
R^2	0.96	0.96	0.96
Mean DV	3.19	3.19	3.19
F-test p value	0.000	0.000	0.000

Notes: The table shows regressions of the log of cocoa deforestation exposure in hectare (ha) by a buyer b in a year y to a destination d from a seller s. The main regressor in all cases is the baseline, buyer-specific metric of relational sourcing and it is standardized. Business Manager is a dummy that takes value 1 if the CEO has a business major. Controls include (log of) export volumes, (log of) price, and (log of) land use exposure ha. We report the p-value for the F-test testing the difference between the coefficients at the bottom of the table. Standard errors clustered at buyer-year-level in parentheses. * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

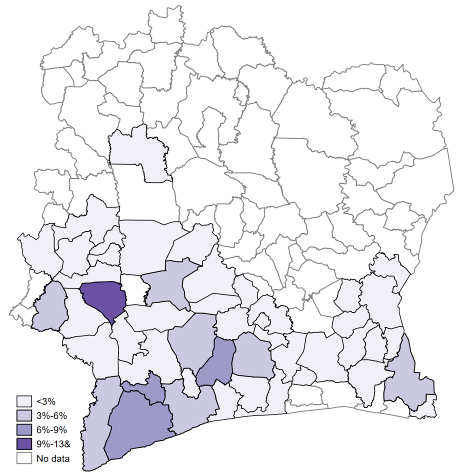
A.2 Figures

Figure A1: Cocoa deforestation in Côte d'Ivoire



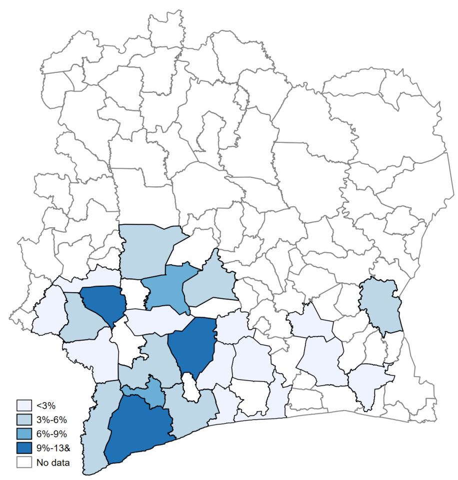
Notes: This figure shows cocoa deforestation (ha) in 2019. Calculated by identifying the total cocoa area in the target year that overlaps with the loss in undisturbed tropical moist forests for the 15-year period that begins 19 years before the target year (i.e., allocation period: 15 years, time to first harvest: 4 years). Source: Trase.

Figure A2: CARGILL Deforestation Exposure by Department



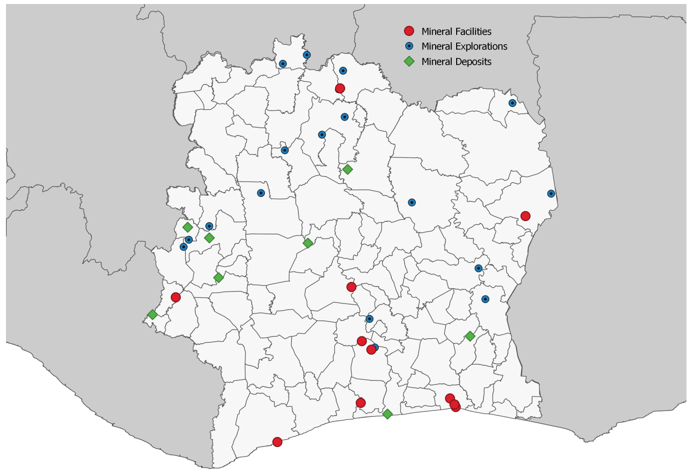
Notes: CARGILL Deforestation Exposure by department in the year 2019 for The Netherlands as destination from the seller ETC.

Figure A3: ECOM Deforestation Exposure by Department



Notes: ECOM Deforestation Exposure by department in the year 2019 for The Netherlands as destination from the seller ETC.

Figure A4: Mineral activities



Notes: Location of Mining activities in Ivory Coast in 2021. Source: U.S. Geological Survey (Padilla et al., 2021)

A.3 Supply chain mapping method

We use the supply chain model developed by Trase (called SEI-PCS) in the context of cocoa in Côte d'Ivoire to quantify the exposure of every buyer to deforestation for cocoa. Trase open data offering readily provides the cocoa deforestation exposure (CDE) metric we use, but aggregated at different levels than that of buyers, which is our focus here. Therefore, we rerun the model to be able to aggregate the CDE of individual trade flows to the buyer level. Other than this different level of aggregation, we follow the exact same method as the original model, which is fully explained in Trase (2024). This method, repeated for each calendar year from 2019 to 2021, has three main parts.

First, we consider individual transactions in Ivorian customs declarations for five different HS codes (for cocoa beans, defatted and not defatted cocoa paste, cocoa butter and cocoa powder). We convert the volumes of every transaction into cocoa bean equivalent volumes, using the conversion factors of the International Cocoa and Coffee Organization (ICCO). We then assign individual transactions to buyers. This involves the curation of the importer names in customs data into a dictionary of matches between clean buyer company names and misspelled names or subsidiary names. We use the same dictionary as for the other two exporting countries (built upon the one used by Trase for exporter names).

Second, we estimate the share of the total volume handled by each buyer that originate in each department. For that, we rely on companies' public disclosures of the cocoa cooperatives they buy from and of the number of farmers supplying them through each cooperative. We convert this into cocoa bean volumes by using the nationally representative average production of 1.2 tonnes of cocoa per farmer per year (Bymolt et al., 2018). For buyers whose companies have not made any supplier disclosure, we consider the transactions between these buyers and exporting cooperatives in the customs data. We then relate the volumes sourced from cooperatives to the total volume a buyer imports in a year. Adding up these shares within a department gives us the share of a buyer's imports that knowingly originate in this department (under the assumption that cooperatives source from the department they are located in - see Renier et al. (2023) for a detailed discussion of this assumption). Lastly, we multiply these shares by the volume imported by a buyer to obtain the volumes sourced by this buyer in each department specifically.

Third, we calculate cocoa deforestation in each department and combine it with department-specific sourcing to obtain the CDE of a buyer. To measure cocoa deforestation, we use two remote sensing data sets: one that maps tropical moist forest deforestation and forest degradation at a 30-meter resolution every year (Vancutsem et al., 2021), and one that maps cocoa plantations at a 10-meter resolution in 2021 (Kalischek et al., 2023). We overlay both maps to quantify the area of cocoa deforestation in every department: the area where both cocoa plantations and earlier deforestation or degradation can be observed. We add up cocoa deforestation during a 15-year period ending four years before the focal trade year (four years is the time that newly planted trees become productive). By setting these parameters we are assuming that the plantations will be ready for harvesting, and consequently starting to contribute to the volume traded, in the fourth year after the deforestation event. For example, cocoa exported in 2021 was planted in 2017 or earlier (Vancutsem et al., 2021; Kalischek et al., 2023). Finally, we divide cocoa deforestation by the amount of cocoa produced in the department in a given year to obtain the amount of deforestation associated with (i.e., needed for) the production of one tonne of cocoa that year. This can be seen as a measure of the deforestation intensity of cocoa production, at department-year level. This measure, multiplied by the volume sourced by a buyer in the department, gives the CDE of a buyer in a given department. Summing over departments for each buyer gives the CDE of the volumes (knowingly) sourced from cooperatives by each buyer. To this, we add, for each buyer, the product of the remaining volumes and a country-year average of the deforestation intensity of cocoa production. The total is the CDE of a buyer, that we use to measure the environmental footprint associated with this buyer's sourcing choices.