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Effectiveness-equity tradeoffs in enforcing exclusionary supply chain policies: Lessons from the Amazonian cattle sector

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ABSTRACT

To address ongoing deforestation for global food commodities production, companies and governments have adopted a range of forest-focused supply chain policies. In the Brazilian Amazon, these policies take the form of market exclusion mechanisms, i.e., immediately dropping suppliers who have cleared their land after a specific cut-off date. Theory suggests that strict exclusionary policies such as these are likely to result in both negative livelihood effects and reduced effectiveness of the policy if some farmers are not able to comply. It is proposed that a more cooperative model of enforcement that uses flexible and negotiated approaches to compliance management may enable more marginal and disadvantaged farmers to achieve compliance, thereby improving both the effectiveness of supply chain policies and their equity. Through our case study of cattle in the Brazilian Amazon, we examine the degree to which a purportedly cooperative supply chain policy exhibits coercive tendencies at different tiers and the degree to which these tendencies influence effectiveness and equity outcomes of the policy. We show that, surprisingly, even cooperative models of enforcement are prone to exhibit coercive tendencies in multi-tier supply chains, leading to severe equity shortcomings. We provide recommendations and a research agenda to mitigate effectiveness-equity tradeoffs in multi-tier, forest-focused supply chain policies in the aim to improve the design, adoption, and implementation of such policies.

1. Introduction

The tropics contain a majority of the world's biodiversity and forest carbon stocks (Asner et al., 2010; Berenguer et al., 2014), but these ecosystems continue to be threatened by food and mineral commodity production and expansion (Curtis et al., 2018; Pendrill et al., 2019). To mitigate climate change and conserve biodiversity while at the same time improving human well-being in these regions, further commodity production has to be decoupled from ecosystem conversion (Cerri et al., 2018; Lambin et al., 2018; Nepstad et al., 2014). Since the early 2000s, companies and governments have sought to address this challenge by adopting a range of forest-focused supply chain policies (FSPs), including policies that discourage deforestation for commodity production or encourage reforestation on existing farms through the use of market exclusion mechanisms and positive incentives (Garrett et al., 2021a). Today, the adoption of FSPs is an increasingly established part of the marketplace covering large shares of the trade of the major forest-risk commodities (soy, beef, and palm oil), including 85% of Brazilian beef exports, 90% of the Brazilian Amazon's soy exports, and 65% of global palm oil production (Haupt et al., 2018; Zu Ermgassen et al., 2020). FSPs most often take the form of a zero-deforestation commitment (ZDC), where companies promise to exclude production from land deforested after a certain cut-off date from their supply chain (Garrett et al., 2019; Lambin et al., 2018). In the Brazilian Amazon these ZDCs are implemented as market exclusion mechanisms, with buyers aiming to deter deforestation among current and potential suppliers via the threat of terminating the buying arrangement.

It is proposed that exclusionary FSPs have the potential to create stark effectiveness-equity tradeoffs, where effectiveness is primarily defined by meeting conservation goals at various scales (e.g., eliminating products associated with deforestation from the supply chain or generating reductions in deforestation more broadly in a region or sector) (Garrett et al., 2019) and equity refers to producers with different access to resources and capabilities having equal opportunity

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to comply and participate in sustainable markets (Grabs et al., 2021; McDermott et al., 2013; Schielein, 2020; Schneider et al., 2015). These tensions are particularly likely in multi-tier supply chains (for example those of beef or palm oil), where purchasing companies interact directly with first-tier suppliers, who in turn source from upper-tier sub-suppliers (Grimm et al., 2016). Upper-tier suppliers, which in the context of agricultural supply chains are often smaller, poorer farmers, frequently lack the capacity to comply with supply chain policies in forest-risk tropical supply chains (Carvalho et al., 2019; Larsen et al., 2018; McDermott et al., 2015; Villena and Gioia, 2018). This lack of capacity can be behavioral, due to challenges in meeting the land use requirements of the supply chain policy, or bureaucratic, due to challenges in adopting the monitoring and documentation systems required to verify behavioral compliance. To date however, these tensions between equity and effectiveness in supply chain policies remain grossly under-researched (Garrett et al., 2021a; Grabs et al., 2021).

As the broader literature on cleaner production indicates, sustainable supply chain policies are often designed by downstream supply chain actors (retailers, manufacturers and traders) or public actors, frequently without sufficient attention to the implications for upper-tier suppliers, i.e., primary commodity producers (Brockhaus et al., 2013; Maguire-Rajpaul et al., 2016; Meijer, 2015).

One proposed solution to tackle suppliers' potential inability to comply with sustainability policies is the "cooperative" (or flexible) enforcement of requirements, where actors that have established policies engage with suppliers, rather than excluding them immediately from the supply chain. In this enforcement model, targets and timelines for compliance are negotiated with suppliers to better match their resources and abilities. The cooperative model stands in contrast to a "coercive" (or deterrence based) approach (cf. Earnhart et al., 2020; Earnhart and Glicksman, 2015; Potoski and Prakash, 2004) that relies on the threat of market exclusion regardless of differences in suppliers' ability to comply.

The existing supply chain literature suggests that these cooperative approaches can result in a greater balance between effectiveness and equity, by improving compliance by suppliers (e.g. Brockhaus et al., 2013; Grimm et al., 2016; Mena et al., 2013; Wilhelm et al., 2016a). Yet, the focus of this literature is largely on how the strategies of downstream firms influence the activities of their direct or indirect suppliers, not how they impact the regional supply base more broadly. It remains poorly understood if and under what conditions the potential equity benefits of the more cooperative model extend beyond the direct (first-tier) suppliers to the indirect (second- or third-tier) suppliers. This is a major shortcoming of literature because bottlenecks due to effectiveness-equity tensions may slow down sustainable supply chain policy implementation in these sectors or further exacerbate precarious supplier livelihoods (Collins, 2019; Garrett et al., 2021a; Grabs et al., 2021; Rothrock et al., 2019). In the case of FSPs, the lack of effective and equitable implementation has major negative implications for climate change mitigation and global development, since the agricultural systems they target are both the leading cause of deforestation and a major employer of rural households (Lambin et al., 2018).

In this study we attempt to understand the degree to which a purportedly cooperative supply chain policy exhibits coercive tendencies at different tiers and the degree to which these tendencies influence effectiveness and equity outcomes of the policy, with a focus on market access equity (Grabs et al., 2021). We bring together theoretical insights from the environmental policy and supply chain management literatures and explore them empirically with a case study of an FSP that is purportedly based on cooperative enforcement, the *Terms of adjustment of conduct* (*Termos de Ajustamento de Conduta*, or TAC) agreement.[1] The TAC agreement is led by Brazilian public prosecutors (Ministério Público Federal, or MPF) in collaboration with cattle slaughterhouses and the beef industry (Walker et al., 2013) and aims to reduce deforestation for beef cattle production in the Brazilian Amazon. Our work draws on both secondary information and in-depth qualitative field research conducted in the state of Pará between October 2019 and February 2020. Through this case we provide an empirical contribution of how the existence of multiple tiers of suppliers with heterogeneous compliance capacities hinders both the effectiveness and market access equity of a purportedly cooperative supply chain policy, making it de facto coercive at higher tiers.

2. Literature review

2.1. Effectiveness and equity of FSPs

Recent evaluations of FSPs have largely focused on their effectiveness in reducing deforestation or increasing forest cover across various scales and their direct impacts on farmers' incomes, while equity outcomes have been less often assessed (Garrett et al., 2021a). An FSP is equitable from a market access perspective if it grants "equal opportunity of different groups of producers, particularly those with high and low adaptive capacities, to participate in a ZDC supply chain" (Grabs et al., 2021). Both the effectiveness and the market access equity of FSPs can be assessed at different scales, ranging from the single supply chain to a global level, which also takes into account unintended effects and spillovers from single-commodity FSP to other commodities, regions, and actors (Garrett et al., 2019; Grabs et al., 2021).

Previous work suggests that FSPs are likely to have greater effectiveness in reducing deforestation when they have: i) a broad scope that includes all the actors and market segments of the targeted value chain, ii) stringent, well-defined, implemented criteria that do not overlap with other policies, and iii) when the actors making the policies collectively control most of the market, reducing opportunities for suppliers to evade their requirements (Garrett et al., 2019). However, if the market access for noncompliant suppliers is reduced as a result of a highly stringent policy, those actors may see reduced income and a weakened position (Hill and Higman, 2017). This is especially true if the non-compliant actors were already the most economically marginalized producers (Grabs et al., 2021).

Negative equity impacts may in turn undermine effectiveness. Excluding suppliers that are unable to comply may be perceived as unfair, which may crowd out motivations for compliance, increase resistance to change and create the political environment to slash environmental protection (Brockhaus et al., 2013; Fehr and Gächter, 2000; Ford et al., 2008; Pereira et al., 2020a). Furthermore, the exclusion of suppliers that are unable to comply with an FSP may undermine its effectiveness if those suppliers continue clearing their land and selling to non-committed companies, a form of leakage (Meyfroidt et al., 2020).

2.2. Cooperative and coercive enforcement models in environmental policy and multi-tier supply chain management

Despite the inherent effectiveness-equity tensions in designing FSPs, it has been proposed that specific design choices can help balance effectiveness and equity concerns (Grabs et al., 2021). These design choices involve, among other choices: i) involving affected actors in the co-production of implementation mechanisms and enforcement solutions and ii) use equal monitoring but differentiated enforcement. With respect to the latter, the more cooperative enforcement model is proposed as an alternative to a traditional coercive approach which aims at deterring non-compliance through punitive measures – i.e., exclusion.

With its focus on deterrence, coercive models implicitly assume rational, perfectly informed profit-maximizing actors. It is expected that compliance will occur if the net expected benefits of doing so exceed the benefits of non-compliance (i.e., gains in income minus risk of exclusion) (Becker, 1968; Kagan et al., 2003; Malloy, 2003; Spence, 2001). The

[1] A list of the acronyms in Portuguese language is provided in appendix.

cooperative enforcement model aims to induce compliance through flexibility, and assumes a general inclination to comply, based on civic and societal motives (Rechtschaffen and Markell, 2003). It relaxes the assumption of perfect information and emphasizes education, innovation and selected enforcement based on specific circumstances of non-compliance (Earnhart and Glicksman, 2015). The most important element underpinning the feasibility of the cooperative model is the ability of regulators and suppliers to collaborate effectively (Clark, 2017; Pires, 2008; Potoski and Prakash, 2004), so that regulators can effectively assess suppliers' compliance and also distinguish their motivations from their abilities to comply (Wilhelm et al., 2016a).

In the supply chain management literature, the enforcement of corporate standards in the value chain is often conceptualized as the "assessment and collaboration" (A&C) (Sancha et al., 2016) of a buyer or supplier with their upstream suppliers. Assessment refers to the monitoring and selection (and therefore exclusion) of suppliers based on their ability to comply (a form of coercive enforcement), and collaboration occurs to bring suppliers up to desired compliance levels (cooperative enforcement) (Grimm et al., 2016; Villena and Gioia, 2018). With the exception of chain of custody certification, supply chain sustainability policy implementation has traditionally focused on direct suppliers only (for a list of actions undertaken by companies to achieve collaboration with suppliers see Bai and Sarkis (2010)). Yet, increasing societal pressure for companies' accountability beyond the traditional boundary of the firm has pushed buyers to apply A&C further upstream (e.g.Villena and Gioia, 2018). In response, an emergent literature identified a number of factors affecting the emergence and effectiveness of A&C involving indirect suppliers, and mapped different ways to engage them (cf. Grimm et al., 2014; Mena et al., 2013; Tachizawa and Wong, 2014; Wilhelm et al., 2016a; Wilhelm et al., 2016b). A&C can be implemented *directly* from the buyer to its indirect suppliers - individually or in consortium with other buyers (Lechler et al., 2019), *delegated* to direct suppliers, or *mediated* by third parties (such as NGOs or assessment companies, e.g. Cole and Aitken (2020)).

In multi-tier tropical commodity supply chains, the supply chain widens upstream (with many individual direct and indirect suppliers to the first-tier), and enforcement of supply chain policies is often delegated to first-tier suppliers (Grabs and Carodenuto, 2021). The overall potential impact of cooperative or coercive enforcement models thus becomes more complex because mid- and downstream actors' implementation behavior produces a cascade of potentially unexpected effects on the upper-tier suppliers (Fig. 1).

A first-tier supplier (typically an intermediary such as a trader or slaughterhouse) acquires a 'double agency' in sustainability management (Fig. 1), where it is responsible to (i) "act as an agent toward the lead firm when implementing sustainability in its own operations" and also to (ii) "act as an agent for disseminating sustainability standards to its suppliers' operations" (Wilhelm et al., 2016b p. 44, Grimm et al., 2016). In a parallel sense, when applied to public-private partnerships for policy implementation, first-tier suppliers become 'double agents' of a regulator that delegates governance power to them due to their enhanced competencies (e.g. expertise, credibility, legitimacy, or just operational capacity) (cf. Abbott et al., 2019) and the ease of interacting with a lower number of actors.

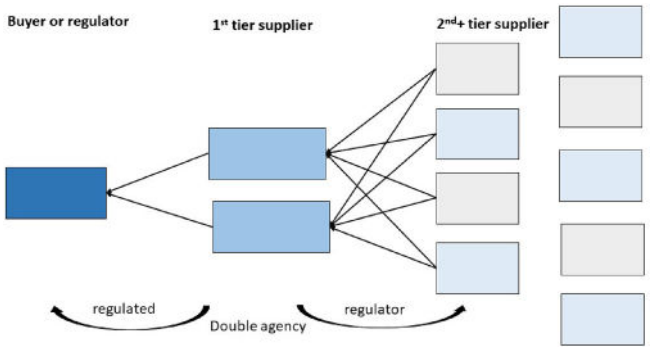

Fig. 1. Stylized representation of multi-tier tropical commodity supply chain.

Tropical commodity supply chains are usually multi-tier, broaden upstream and contain producers with highly heterogeneous compliance abilities. In the case study presented below, slaughterhouses are first tier receiving the FSP from the Brazilian Public Prosecutor (MPF) and implementing it with respect to cattle suppliers (the second and third tiers).

Due to the double agency situation, intermediaries (e.g. traders, slaughterhouses) become crucial to effectiveness and equity outcomes because they must fulfill the objectives of the regulator (or the downstream buyers), by passing sustainability requirements on to upstream suppliers (thereby ensuring the implementation of requirements). Previous case studies show that increased market power by first-tier suppliers, reduced information asymmetries (i.e. vertical integration), and low engagement costs increase the likelihood of first-tier suppliers to disseminate sustainability requirements upstream (Grimm et al., 2016; Wilhelm et al., 2016b), but they create concerns for potential adverse effects of market concentration (cf. Pereira et al., 2016; Vicol, 2017) and marginalization of less able producers (Lambin et al., 2018; Vicol et al., 2018). Further, exclusion, enforcement of compliance, and integration may jeopardize business relationships. Delegated enforcement may be perceived as an unfair task by first-tier suppliers, illegitimate by second-tier suppliers, and reduce the FSP's buy-in, increasing resistance to change.

Although the potential of cooperative enforcement to induce compliance is recognized in both the environmental policy and business literature, the environmental policy literature does not yet theorize its application to supply chains, and the business literature fails to relate it to higher-level effectiveness beyond the focal firm supply chain and to equity implications (e.g. by accounting for excluded suppliers) (cf. Rajeev et al., 2017). This gap in the literature is reflected in industry practice, with companies piloting several different ways to engage indirect suppliers in all tropical commodity sectors (Grabs et al., 2021). In some sectors this involved substantial delay in the cutoff implementation date for sub-suppliers. For instance, major Brazilian meatpackers moved their deadlines back to 2025–2030. Indonesian palm oil companies confront this challenge by aiming to map and educate smaller and independent suppliers, but often do not monitor their land use. Finally, strategies to engage indirect suppliers is yet to be announced in the West African cocoa sector (Grabs et al., 2021), though indirect suppliers constitute up to 50% of companies' supply chains (Carodenuto and Buluran, 2021). Limited knowledge about how to increase suppliers' ability to comply with FSPs requirements has obvious negative implications for climate change mitigation and global development (Lambin et al., 2018).

In the following section we introduce the case study and methods used to explore the potential tensions between equity and effectiveness in FSPs. Building from the above theoretical framing we then examine the potential importance of supply chain tiers, supplier compliance motivations, and compliance abilities in influencing effectiveness-equity tensions in FSP implementation under a purportedly cooperative enforcement model. First, we examine the degree to which the TAC agreement exhibits cooperative versus coercive mechanisms at various tiers and then describe the likely effectiveness and equity impacts of TAC enforcement based on the results of secondary data collection and our interviews with supply chain actors.

3. Case study and methods

3.1. Case study background: TAC and cattle in the Brazilian Amazon

In Brazil, public deforestation regulations tightened from 2002 to 2012 (cd. Assunção and Rocha, 2019), but in more recent years and

under the administrations of Michel Temer and Jair Bolsonaro public support for reduced deforestation has substantially contracted (Carvalho et al., 2019; Reydon et al., 2020). The Federal Police and Brazilian Environmental Agencies (IBAMA and ICMBio) have received substantial backlash, such as media attacks, funding and personnel cuts, and personal threats to high ranking officers (eg. Carvalho et al., 2019; Mello, 2017). In this context of hostility and retraction of standard command-and-control policy instruments, the role of independent public prosecutors (MPFs), private forest-focused policies, and more cooperative enforcement strategies has become an increasingly important entry point for deforestation control (Garrett et al., 2021b).

Cattle ranching is by far the largest direct driver of deforestation in Brazil (Tyukavina et al., 2017) and consequently the largest driver of deforestation globally (Curtis et al., 2018; Pendrill et al., 2019; Tyukavina et al., 2017). As of 2017 the Brazilian Amazon had 390,000 cattle farms supplying 38 main slaughterhouse companies (Barreto et al., 2017). The meat sector is concentrated, with the three largest companies (JBS, Minerva and Marfrig) slaughtering 66–71% of the total amount (Vale et al., 2019). These slaughterhouses in turn are first-tier suppliers for a number of large multinational retailers such as Walmart, Carrefour, and the Casino Group, as well as global brands such as Unilever or Mars (NWF, GLUE, 2020). For a long time meatpackers in the Brazilian Amazon sourced cattle irrespective of its legal or illegal origin and absent of any monitoring tool (Gibbs et al., 2016). However, recently both public and market backlash occurred against this operating mode.

The *Terms of Adjustment of Conduct* (TAC) is a policy created by the Brazilian federal public prosecutor (MPF) aimed to reduce the deforestation associated with cattle production by forcing signatory slaughterhouses to stop buying from farmers who deforested illegally. TACs began to be signed between the MPF and major meatpacking companies in the state of Pará in 2009, shortly after a shaming campaign by Greenpeace that had led the four major meatpacking companies to sign a zero-deforestation commitment known as G4. Successively, TAC spread to the rest of the Legal Amazon region (Gibbs et al., 2016), and G4 is now monitored within TAC audits (MPF, 2020a). By signing TAC, slaughterhouses avoid judicial action, and commit to no longer source cattle directly from farms illegally deforesting (or deforesting at all after 2009, for G4 signatories), practicing slave labor, encroaching upon indigenous or protected areas, or accused of grabbing public land. For slaughterhouses who do not comply, TAC allows for quick enforcement of sanctions. However, to date only one fine has been awarded to non-compliant slaughterhouses (Mengardo, 2018; MPF, 2019a, b). Instead, the public audits help determine whether slaughterhouses are granted more or less stringent and burdensome auditing criteria for the next year, ranging from requests of information disclosure on a sample basis to mandates of plants inspection (MPF, 2019a).

3.2. Data collection and analysis

By taking a wide and systematic approach we interviewed a diverse sample of actors along the whole supply chain and took a complementary perspective to the largely quantitative knowledge base about G4 and TAC, which has focused on measuring the regional land use outcomes of these policies (i.e., effectiveness) and the correlation of such outcomes with key contextual attributes (i.e., the presence of many indirect suppliers and incomplete market coverage of the committed actors) (e.g., Alix-Garcia and Gibbs, 2017; Gibbs et al., 2016; Levy et al., 2021; Skidmore et al., 2021). Such quantitative studies, if appropriately sampled, are excellent at observing "what" has occurred with some level of generalizability, but struggle to answer causal questions about "why" without an experimental set-up. Qualitative methods are exceptionally well-placed to fill this knowledge gap by answering questions about the mechanisms underpinning an observed outcome within an observational study. Our qualitative approach recognizes that all knowledge is partial and influenced by both the subjects and researchers included in the study and explicitly tries to capture that subjectivity by studying actors' perceptions of reality (particularly equity and fairness), which are considered valid and interesting in and of themselves (Jupp, 2006).

Interviews followed a standard semi-structured interview guide, but allowed for substantial deviation from the guide in order to avoid direct questions about politically or legally sensitive topics that could compromise the interview. As such our data do not have the required repetitive structure to allow for a formal quantitative or comparative analysis. Instead, we tracked each key step in the supply chain's linkages and the reasons underlying agents' choices. For each of these we enquired if and how TAC was affecting choices. Collecting data at each step allowed for a process tracing analysis to be conducted (Bennett and Checkel, 2012; Collier, 2011) where internal validity and robustness was achieved through data source triangulation (Downward and Mearman, 2007; Natow, 2020; Silvestre, 2014) across the responses of buyers, first- and second-tier suppliers and institutional representatives. Whenever possible we also sought further triangulation using secondary data sources, and checked all primary sources mentioned by the interviewee (when used, these are mentioned in text).

Data were collected between October 2019 and February 2020 by the first two authors in the four municipalities of Paragominas, Ipixuna do Pará, Ulianopolis and Dom Eliseu in the state of Pará, Brazil (Fig. 2). The four municipalities are fairly representative of the entire Pará State (Table 1) and Brazilian Amazon in their distribution of small versus large landholdings, representing a wide spectrum of suppliers' abilities. The market share of slaughterhouses that have adopted the G4 or TAC cattle agreements in this region ranges from 63% to 91% (own elaboration based on cattle transaction records from ADEPARA - 2019). This is on the higher end of what is observed throughout the Amazon (cf. Levy et al., 2021). Furthermore, one of the municipalities, Paragominas, launched the first Green Municipality Initiative (*Municipio Verde)*, to generate greater incentives and capacities to counter deforestation, to help the municipality exit a federal deforestation black list of high deforestation municipalities that blocked credit and tax revenue access (which was successfully accomplished in 2011) (Viana et al., 2016). Against this backdrop of higher than average deforestation governance interventions, our case study region would be expected to be at the higher end of environmental effectiveness (due to greater overall pressure), as well as lower equity tradeoffs (due to complementary public governance initiatives) (Grabs et al., 2021).

We aimed to interview all slaughterhouses and live cattle exporters sourcing from the study region. Based on an examination of cattle supply chain data captured by the Trase initiative (www.trase.earth), we identified in total eleven slaughterhouses and one live cattle exporter buying from the study region. We interviewed eight out of the eleven slaughterhouses identified as being among the ten principle cattle buyers in at least one of the four study municipalities. Of the three that were not interviewed, one we were not able to locate, one declined, and a third, sourcing a very small volume, was located very far from the study area and was not contacted.

Thirty-one farmers were purposely selected from a list of cattle farmers based on the Brazilian Rural-Environmental Registry (CAR) and cattle movement records (GTAs). We tried to maximize heterogeneity of farms' features, such as size, distance to the city and asphalt roads, belonging to a green municipality and degree of its implementation, tier in the supply chain, forest cover, dairy and meat orientation, and convenience. In some cases, we followed up (or down) the supply chain by interviewing buyers or suppliers of the selected farm. The sample size was not predetermined and developed from saturation (Saunders et al., 2018).

Finally, we conducted eight interviews with representatives of farmers, meatpackers and live cattle exporters unions, municipal

[2] An agricultural producer is "small" if owning less than four fiscal/tax modules in size, "medium" between 4 and 15, and "large" above 15 (Law 11.326/2006). The specific size of a fiscal module varies across municipalities.

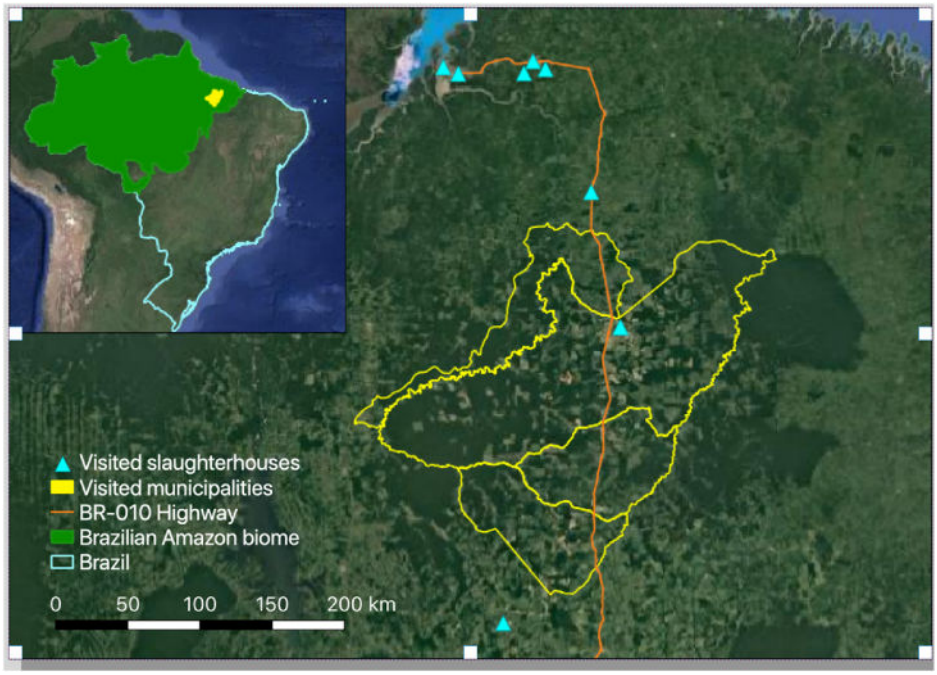

Fig. 2. Study area: From North to South the municipalities are: Ipixuna do Pará, Paragominas, Dom Eliseu and Ulianópolis. Sources: roads: Open Street Map; municipal borders, biome border and national border: Instituto Brasileiro de Geografia e Estatística (IBGE); base layer: Google, 2020.

Table 1
Land ownership in the 4 municipalities (own elaboration on CAR-2019 and IBGE - 2017 Agricultural census)[2].

	Share of properties		Share of land		Cattle herd	
	Study area	Pará state	Study area	Pará state	Study area	Pará state
Small	73%	78%	9%	21%	14%	31%
Medium	12%	10%	11%	8%	86%	69%
Large	15%	12%	80%	71%		

institutions, the animal defense agency (ADEPARA), and the Belém MPF. These interviews were informational and aimed at understanding each organization's role and its relationship with the functioning of TAC. Participant institutions were chosen based on their relevance, assessed progressively along the study. Detailed semi-structured interview guides were devised for each of the three groups (producers, slaughterhouses and institutions) and are reported in the online appendix. An overview of respondents and respondents' features are also reported in Appendix (Tables A1, A2 and A3).

The semi-structured interview guides aimed to obtain comparable information across supply chain actors and were developed based on literature review and over 15 years of cumulative field experience by the authors that developed the guide. We asked how TAC might have affected slaughterhouses and farmers. For slaughterhouses, we probed for direct costs associated with monitoring suppliers, as well as indirect costs associated with a shrinking supply base and working at reduced capacity (or travelling further afield to source cattle). For suppliers, we enquired how they chose buyers, and what their contractual arrangements were. We specifically probed for incentive programs, assistance or credit offered by buyers. We asked about the implementation of TAC monitoring and what their experience with buyers' restrictions was, and if this implied any change in farming (or other) practices. We aimed to capture TAC's impact on individual suppliers in terms of livelihoods, technology and land use, motivations and vision, changes in market access, as well as sectoral level changes, in terms of land use intensification, vertical integration (full cycle farming vs specialization in breeding, raising or finishing).

The topic of the study, environmental policy, is politically sensitive and divisive in Brazil. Laying down the foundations for a trustful interview required up to a full day of personal interaction. In this context, no interview recording was possible. Detailed notes were taken during the interview and revised after the end of the interview. Interviews with institutions were informational and heterogeneous, while interviews with farmers and slaughterhouses were sufficiently structured to allow for coding.

Similar to Findlater et al. (2021), we performed a cross-sectional qualitative analysis. Notes from interviews were analyzed by extracting themes and cases deductively by the predetermined categories identified in the interview guide, but also abductively, allowing for emerging themes. An overview of the themes and case classification structure is given in Tables A4 and A5 in the Appendix. Triangulation is achieved when findings are supported by respondents belonging to different tiers or institutions. Similar to Young and Brans (2017) and Engert and Baumgartner (2016), we document triangulation in the result section by reporting the anonymized identifiers of respondents supporting each finding.

4. Results

4.1. To what degree is TAC cooperatively implemented and enforced at the first tier?

Several characteristics of TAC make it a cooperative FSP at the level of slaughterhouses (the first-tier suppliers). First, the terms of TAC for the meat sector were *negotiated* between the MPF, the four largest slaughterhouses, and the Brazilian association of cattle exporters (ABIEC) and included the obligations of all parties, a timeline of implementation, and sanctions for non-compliant behavior as well as a mechanism for conflicts resolutions. Second, the agreement was based on three pillars: i) the collective construction of consensus based on good will; ii) continuous improvement: expected results should always be the best possible; and iii) a joint search for solutions: organization, criteria, tools (MPF, 2020b). These are maintained and implemented through an *ongoing dialogue* with all parties, public audits, and targeted improvement goals, which are adapted to the audit results and the slaughterhouse ability to comply. Slaughterhouses have the full right to be heard and provide reasons for a potential non-compliance.

Over time, cooperation between the MPF and the meat sector (as well as the implementation of G4) resulted in increasingly clear monitoring and auditing standards by achieving information disclosure from suppliers (specifically regarding suppliers' farm locations and extension via CAR), slaughterhouses and animal health agencies (purchasing and animal transport records), and an emergent private consulting industry providing remote sensing monitoring capacity to slaughterhouses to analyze the above information (gov_1, gov_4, sl_1–8)[3]. Every year since 2018, the MPF audited the purchases of TAC signatory slaughterhouses and measured their compliance by benchmarking slaughterhouses to their own performance in the previous audit, as opposed to require full compliance by handing out hefty fines. This decision was in part driven by the priority of the MPF in Pará to increase the number of TAC signatory slaughterhouses that would subsequently be monitored (gov_1).

About 70% of the meat produced in Pará originated from TAC audited slaughterhouses (gov_1, un_1, un_3; own elaboration on GTA from ADEPARA). Of the eight slaughterhouses we interviewed, two had not signed TAC and were thus not monitored by the MPF. However, both of them implemented a monitoring system, and one excluded most non-compliant farmers, while the other notified non-compliant farmers, though it did not exclude them. Of the TAC signatories, one was close to bankruptcy and thus neither monitored nor excluded farmers due to a lack of financial capacity. The rest were monitoring all purchases and excluding 5%–70% of their supply base (Table A2). The results of the latest MPF (2019a) audit (of 2017 purchases) for the whole Pará state found levels of compliance ranging from 21% to 100% across all TAC signatory slaughterhouses, with an average level of compliance of 93.75% and a minimum of 87% in our study area. Slaughterhouses displaying higher compliance were granted lower auditing costs by conducting audits on a sample of transactions in following years, while others were requested to run audits on all transactions, or were targeted with inspections (MPF, 2019a).

Interviews with representatives of the MPF and slaughterhouses revealed that part of detected non-compliance could originate from methodological differences employed by the monitoring and the auditing companies (sl_2, 6, 7, gov_1, un_3). The MPF believed that a uniform monitoring standard could worsen some companies' compliance performance, reflecting that some slaughterhouses may have abused the flexibility granted within TAC cooperative enforcement. However, shortly after the end of the study period, a working group of civil society, meatpackers and the MPF had defined uniform standards to be applied from the following audit (MPF, 2020a), displaying how cooperative enforcement provided new solutions and adaptability.

4.2. To what degree is TAC cooperatively implemented and enforced among 2^{nd}+ tier suppliers?

While TAC implementation was strongly cooperative at the level of slaughterhouses, there was little evidence of cooperative enforcement further upstream. By design, TAC expects slaughterhouses to monitor their suppliers' behavior before each purchase and exclude non-compliant suppliers from their supply chain. While the policy was built in a consultative process with the beef sector (gov_1, un_1, un_3), there is no provision for how (and if) non-compliant cattle suppliers should be engaged with beyond market exclusion (cf. MPF, 2020a). The TAC agreement states that farmers' regularization (resolution of environmental and tenure issues) is to be dealt with by the respective state and federal agencies, thereby not including any mechanisms to increase flexibility for farmers. Meeting TAC criteria for farmers requires substantial education (to navigate legal documents) and/or financial capacity (e.g. to hire consultants/lawyers) (sl_1–8, gov_3–5, un_1). Slaughterhouses may choose to pass on the full costs of compliance to suppliers, or to mitigate them – for instance through capacity building and credit (e.g. advanced payments) – but there was no apparent incentive to implement mechanisms that enabled compliance of weaker actors (Brandão et al., 2020; Pereira et al., 2020b).

Additionally, farmers and slaughterhouses met in a competitive market dominated by spot contracts and have historically entertained conflictual relationships characterized by little coordination and value appropriation by the latter through manipulation of payment standards (de Oliveira et al., 2017; Rosales et al., 2019), with unclear horizons for investments in compliance on both parts. All TAC signatory slaughterhouses reported travelling longer distances to find cattle, rather than trying to establish long-term relations with closer farmers (sl_1–3, sl_6–7). Slaughterhouses pointed to regularization guidelines and procedures to exclude farmers, but did not provide dedicated enabling tools such as advanced payments or educational workshops (sl_1–3, sl_6). Ultimately, they didn't perceive a return on investing in their suppliers' compliance, as initially suspended farmers would find other buyers (sl 1–4, 6, 7). When asked about their relationship to slaughterhouses, no farmer ever mentioned receiving assistance from slaughterhouses or buyers to achieve compliance. Security of payment (27 cases), price (10 cases), payment time (5 cases), and ease of sale arrangements (4 cases) were the only mentioned reasons to choose selling to a particular slaughterhouse, indicating features of a market with no consolidated buyer-seller relationships.

Farmers' difficulty of complying with TAC appeared disproportionate compared to that of slaughterhouses (see table A6 in Appendix). The seven slaughterhouses implementing monitoring had one or two full-time employees dedicated to monitoring and were relying on private consulting services that were validating eligibility of potential suppliers, analyzing documents of farmers appealing against exclusion decisions, and suggesting appropriate procedures to regularize non-compliant farmers. The cost of the monitoring consulting services also appeared to be inexpensive and ranged between 5k and 20k BRL per month. On the other hand, slaughterhouses reported that at the moment of implementation, farmers perceived the monitoring and enforcement of criteria as unfair. The most dominant shortcomings were: 1. a lack of clear communication criteria prior to exclusion *"Writing the law it's easy, applying fines too. But producers only receive information when the sanction comes"* (sl_2); 2. stiff criteria that exclude farmers regardless of few or thousands of hectares of illegal deforestation (sl_2; sl_6, 7); 3. that in the face of an automated exclusion system based on satellite monitoring (PRODES) - perceived to be prone to produce false positives -, the real burden of proof was borne by the farmers, who have to engage in long, costly and bureaucratic processes of appeal and regularization (sl_1–3, 6, 7; un_2–3; gov_4, 5; t2p_6, 8; t3p_1–3, 8, 10, 12, 13).

4.3. What is the likely effectiveness of TAC in preventing on-farm deforestation?

Interviews pointed to several factors that limit the effectiveness of TAC in meeting its policy goals, including its redundancy with respect to other policies, the scope limited to slaughterhouses and their direct suppliers, which allowed farmers to find a multitude of other buyers, and the multiple opportunities to launder cattle (cf. Pereira et al., 2020a).

Redundancy with respect to other policies: TAC requirements overlapped with environmental and labor laws (gov_1–5, un_2–3). In some instances farmers' compliance preceded TAC implementation. At the time of interviews, eleven out of 13 direct suppliers of TAC signatories reported being already compliant prior to the introduction of buyers' restrictions and as a result of satellite monitoring and on-site police enforcement (started in 2004).

Indirect suppliers and dairy farms were not within TAC scope: Indirect suppliers did not perceive changes in buyers' requirements, as they were not within the scope of TAC restrictions. Seven out of eleven smallholders were not aware of TAC requirements, because they had never

[3] gov = government agency, un = producers' union, sl = tier 1 slaughterhouses, t2p = tier 2 producers (fatteners), t3p = tier 3 producers (calvers).

interacted with a TAC signatory. This happened although the distinction between direct and indirect suppliers is imperfect, because all calves and dairy producers do sell old breeding and dairy cows for slaughter, these inferior cattle quality and breed were typically absorbed by local butchers or non-signatory slaughterhouses selling within the municipal or state markets (Fig. 3). The latter two were reported to offer higher prices for the quality compared to signatory slaughterhouses, but only to large producers doing business with both types of buyers (t3p_9, 12).

Cattle suppliers with multiple properties (owned or rented) have the opportunity to launder cattle: Farmers were able to use the lack of monitoring of indirect suppliers to launder cattle by moving animals across farms before selling to a slaughterhouse, particularly between properties within their own portfolio of farms. We observed laundering for both farms selling to slaughterhouses (t3p_3, 6) and selling live cattle for export (t3p_10).

Insufficient market share for change and bifurcation of market: Though TAC covers around 70% of cattle purchased in Pará, non-compliant producers could sell cattle to intermediaries, non-TAC slaughterhouses, backyard butchers or other farmers.

To our surprise, none of the 31 interviewed farmers ever reported difficulties in selling cattle unsolicited. The general sentiment was that "*cattle sells as easily as gold*" (t2p_5). Yet smallholders reported facing insurmountable barriers to access slaughterhouses, even setting aside compliance with legal requirements. For instance, nine of eleven smallholders lacked the sales volumes to compensate for transport costs, the breed of their (usually dairy) cattle was not procured by larger slaughterhouses, and animals were typically sold in need of cash rather than when the animals reached the optimal slaughtering age. Additionally, smallholders did not own sufficient pasture, capital and knowledge to fatten cattle, and eight out of eleven specialized in breeding.

When the technical barriers above were overcome (e.g. by cooperating to meet the required sales volumes – t2p 8, 9, 18), farmers lacked documents required to sell to TAC signatory slaughterhouses such as CAR, land titles and GTAs. Lacking the possibility to comply with the required paperwork, smallholders typically sold cattle to intermediaries who were able to produce documents through their farms, or directly to butchers using CAR from neighboring farms (t2_p1, 11, t3p_4). Farmers selling cattle in the informal sector complained about risks of fraud and preferred selling to well-known local buyers and therefore had very limited bargaining power (t2p_1, 2, 3, 4, t3p_1). Calves prices were reported to vary from one smallholders' settlement to another only a few tenths of kilometers apart, signaling strong market power by cattle buyers, operating in a virtually uncontested monopsony.

Slaughterhouses confirmed an increasingly bifurcated market. Meatpackers sourcing from small and medium farmers and selling to lower market segments were those excluding a higher share of their suppliers – up to 70% (sl_2) versus 5% (sl_7) for the most established plant in the study area. Yet there always appeared to be a buyer for such non-compliant producers. As reported by a meatpacking unions representative: "*[Complying with TAC] is like trying to separate arroz e feijão [mixed rice and beans], it is difficult. And when you discard the beans, someone comes, sits beside you, eats both their rice and beans and your beans too*" (un_3).

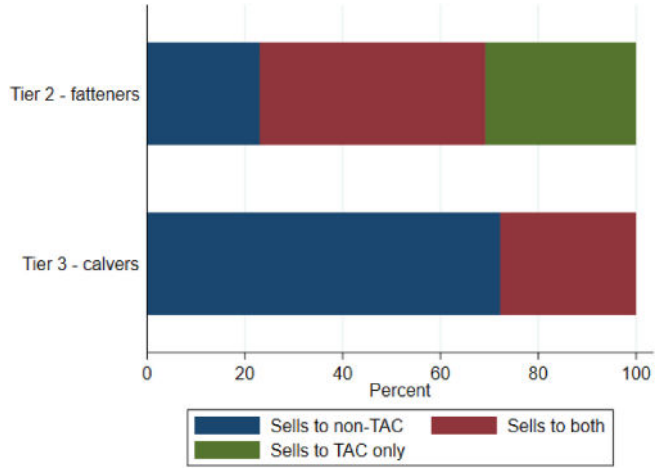

Fig. 3. Buyer choice by suppliers' tier.

5. What are the likely equity impacts of TAC amidst broader sectoral trends?

The low market share and narrow scope of TAC restrictions, which reduces TAC's effectiveness, appeared to be mitigating the negative equity effects of the mechanism as well. The cattle market was highly segmented, and all farmers were able to find a buyer, regardless of their compliance with TAC criteria. For marginalized farmers selling small volumes or lower-quality breeds this came at the cost of low market power and prices (e.g. t2p_1, 10, t3p_1, 4, 5), which would be further reduced if the TAC design criteria were made more stringent, i.e. if farmers providing inferior breed and low volumes would face an even smaller market.

Market bifurcation and the consequent lower prices were perceived to be driving the exit of smaller farmers from cattle ranching to other land use activities or entirely out of agriculture, contributing to land concentration (t3p_5, 11, un_1, gov_1). Documenting exit and its causes is difficult, because farmers that abandoned cattle ranching are not easy to identify. However, during interviews it was reported that many small and medium cattle farms were purchased by large cattle ranchers (t2p_11), and that local butchers who used to rely on locally-sourced smallholder cattle, were forced to close or scale down their businesses as a consequence of supply shortage (t2p_2). Indeed, we had trouble identifying and interviewing medium cattle farmers in our study area since most of the visited farms that appeared as medium-sized from their property boundaries were in fact part of larger land holdings, which is a signal of the land concentration process. In the words of a farmer that at the age of 29 had concentrated 35,000ha on 64 small and medium farms: "*If the trend continues, in 10 years small and medium farmers are going to be extinct. If the government does not attempt to change the law to regularize smallholdings, in ten years there is going to be only large farmers. And this is bad. The more competitive, the better the market works. The market in the hands of a few, this is no good*" (t2p_5).

Yet it was unclear how these transitions were linked to supply chain policies versus broader policy and economic stimuli. Larger farmers perceived a tendency to integrate production as a way to maintain profit margins, in a phase of the business cycle characterized by rising costs, calf scarcity and increasing grain availabilities. According to large farmers, vertical integration of cattle production to encompass the "full cycle" (i.e. raising cattle from birth to slaughter) increases profit margins by "diluting fixed costs", increasing productivity (e.g. through cattle confinement to feed-lots and integration with agriculture, which speed up weight-gaining and frees up pasture for calves raising), and reducing supply chain risks associated with uncertain supply of calves and ensuring genetic control (e.g. through artificial insemination) (t2p_4, 5, 8, 9, 10, 11, 12, sl_3, 6, 7). Full cycle farming was also a strategy promoted by a meat packer to reduce the environmental risks associated with indirect suppliers (e.g. The Economist, 2020). Vertical integration and land concentration could be further increased if TAC criteria were extended to indirect suppliers. However, changes in vertical integration, like farm consolidation, could not be exclusively linked to changes in supply chain regulations.

6. Discussion

6.1. Summary of findings

We found that TAC exhibits largely cooperative characteristics at the level of first-tier suppliers (the slaughterhouses). On the whole, cooperative enforcement at the first-tier appears to increase its effectiveness and equity by separating genuinely non-compliant suppliers from those that are unable to comply. Cooperative enforcement allows for increased compliance among slaughterhouses by establishing improved transparency and monitoring, whilst accommodating different abilities to comply through a constant dialogue that guarantees continuous improvements. In taking a collaborative path, the public authority (MPF) established relationships of trust with first-tier suppliers and created mutual understanding and innovative solutions. Slaughterhouses with greater difficulty in meeting compliance standards were evaluated against their own performance in the previous year, and were given time to adjust to new expectations of legal compliance.

The same flexibility was not granted to their sub-suppliers. We found no evidence of capacity building or supportive actions by slaughterhouses. Instead, implementation dynamics were dominated by surveillance, mistrust, and frustration by farmers. The fact that upstream implementation of TAC defaulted to a coercive implementation system meant that implementation progress plateaued at a level that allowed some slaughterhouses to claim high compliance, but did not address the root problem of slowing commodity-driven deforestation. Cooperative enforcement with first-tier suppliers (or buyers) did not translate into cooperative enforcement for upper-tier suppliers, especially when market share was low. Absent specific incentives, slaughterhouses were not motivated to provide remedies to the lack of ability to comply of weaker cattle-ranchers. Instead, they increased their sourcing radius without further engaging with non-compliant suppliers, creating room for inequity and leakage.

The coercive fashion in which TAC slaughterhouses implemented their policies, in addition to the limited scope of the policy and the presence of widespread cattle laundering, appears to have contributed to further bifurcation of the formal and informal meat markets in Brazil. This allowed on-farm deforestation to continue, as deforesting actors had sufficient outlets for their cattle that TAC criteria were not binding in their decision-making. The inferior conditions of the informal market, coupled with insufficient capacity to access formal markets likely contributed to the ongoing exit of smaller producers, and vertical integration.

Compliant buyers operating with the lower quality segment of the market displayed high exclusion rates (up to 70%). Yet, the limited market share and narrow scope of TAC mitigated negative equity effects, because calves and dairy farms of all size and ability were able to sell cattle to non-TAC-signatory buyers. Yet, the high level of non-compliance among third-tier suppliers and lack of cooperative enforcement upstream created an equity bottleneck to the adoption of a wider scope and more stringent TAC criteria. Unless specific provisions are taken to ensure fair inclusion of small and medium farmers, the scope of TAC is unlikely to expand to indirect suppliers.

The lack of cooperative enforcement upstream appeared to undermine small and medium producers' market access. It was perceived to increase the likelihood of them exiting the market and had the potential to increase land concentration in the sector, further increasing power and assets inequality and potentially threatening food security. Additionally, concentration of smallholders' land has been associated with increasing deforestation and degradation (de Almeida et al., 2020; Yanai et al., 2020). Smaller producers faced lower prices in the informal market, while larger producers had incentive to expand simultaneously vertically and horizontally to secure supply of calves and increase efficiency. That these phenomena preceded TAC and are related to ongoing trends and structural problems of market access, education, poverty and power (Boyd, 2008) raises the question of whether FSPs can disregard or should address the social problems of the environment in which they operate.

This theoretical and empirical analysis points to three broad hypotheses that should be further explored in future research:

1. Cooperative enforcement (at least at the first tier) increases the effectiveness and equity of FSPs by separating genuinely non-compliant suppliers from those that are unable to comply, accounting for suppliers' different abilities to comply, and allowing for stronger design criteria that increase effectiveness without harming equity.
2. However, cooperative enforcement in the first-tier is likely to become coercive upstream without clear mandates for cooperation, leading to negative effectiveness and equity outcomes.
3. Coercive enforcement at any tier, but especially upper tiers, creates effectiveness-equity tradeoffs, with the balance of effectiveness versus equity outcomes tilted towards effectiveness the higher the market share and the broader the scope of the FSP.

6.2. Policy recommendations: enabling effective and equitable cooperative enforcement in multi-tier supply chains

In light of these findings, how should TAC deal with heterogeneous suppliers' capabilities? And how should FSPs governing multi-tier supply chains enforce requirements in a way that does not produce discrimination in market access equity? For cooperative enforcement to work, decisions should be taken by actors that are able to observe both compliance, motivations and ability to comply of (sub-)suppliers, and the regulator (buyer or governmental authority) should set incentives such that such agents (e.g. direct suppliers) have interest in cooperating with indirect suppliers for compliance, but not to extract the indirect suppliers' rent. This is challenging because of asymmetric information, market power concentration downstream, general incentives misalignment and substantial transaction costs between the direct and the indirect suppliers when these are not integrated (Brockhaus et al., 2013; Dou et al., 2018; Grabs and Carodenuto, 2021; Grimm et al., 2018; Klassen and Vereecke, 2012; Vachon and Klassen, 2006; Wilhelm et al., 2016a). For instance, Brandão et al. (2020) found that slaughterhouses in São Félix do Xingu were providing resources for farmers to adopt CAR, but later formed an oligopsony to push down prices.

To ease cross-tier cooperation the regulator – e.g. the MPF – could fulfill the role of "network broker" (Saunders et al., 2019) and coordinate efforts from government agencies and civil society to increase transparency, by making information about the indirect supplier compliance easily available for the direct supplier. It might also incentivize small and medium suppliers' regularization through preferential access to credit and technical assistance upon presentation of a purchasing guarantee by the direct supplier (i.e. well-regulated long-term contracts) (Klassen and Vereecke, 2012; Vachon and Klassen, 2006), transferring the incentive to report and monitor progress on the direct supplier, while freeing the supplier from risks associated with contract farming. Alternatively, a standard but participatory contract involving direct provision of credit, technical assistance and small and medium suppliers' safeguards can be devised, as for the Brazilian Sustainable Palm Oil Production Program (SPOPP), which also guarantees a sourcing quota from smallholders (Benami et al., 2018; Brandão et al., 2018; de Almeida et al., 2020). In both cases a longer contract term and stable business relationship across indirect and direct suppliers would benefit

both parts, by establishing a certain return for investments in compliance for the first and reducing costs for the latter to monitor and collaborate with indirect suppliers (Klassen and Vereecke, 2012; Vachon and Klassen, 2006).

For effective and equitable enforcement to work, actors should be able to credibly signal their willingness to cooperate (Potoski and Prakash, 2004) across tiers, and the development of technologies that enable effective monitoring and dialogue across tiers are key to achieve this. The regulator must be able to interact with suppliers, to monitor suppliers' behavior, and to send credible signals about sanctions. It must be independent of the judicial and executive powers, so that political lobbies, government and election cycles do not affect the certainty of monitoring, and sanctions execution (Reydon et al., 2020). Suppliers need to be able to interact with the regulator (e.g. providing legitimated representatives); they must be visible, liable to penalties or public shame by civil society organizations (cf. Grimm et al., 2016); and they should manifest good will, i.e. the willingness to disclose information, the vision and ability to translate compliance into value, and minimum legalistic values (cf. Mammadova et al., 2020). In this sense, the institutional environment of the FSP appears as a key enabling factor of private initiative success, providing sufficient rule of law, monitoring and sanctioning infrastructure, and support suppliers' societal values.

6.3. Limitations and future research

Our analysis did not consider the opportunity to devise FSP criteria that are differentiated for each actors' group. However, this does not invalidate the need for cooperative enforcement, as heterogeneity of abilities likely persist within groups targeted by differentiated criteria, e.g. efficiency and needs vary substantially among smallholders (Schneider et al., 2015; Schoneveld et al., 2019).

We did not enquire about equity impacts related to the FSP design that do not refer to the enforcement strategy, such as those related to cutoff dates for the entry into force of the agreement, which advantages suppliers in consolidated frontier areas over those in new frontiers.

We did not consider political risks involved with cooperative FSPs, which may legitimate a narrative in which deforestation free (legal) products should be awarded a higher market status (e.g. a price premium), rather than assuming that deforestation free products should be the default (Mammadova et al., 2020). This narrative could legitimate agribusiness expansion over forest within legal requirements that are increasingly slack (cf. Guéneau, 2018; Soares-Filho et al., 2014), and provide support to the perception that all costs of conservation should be compensated, either directly or through a market premium, crowding out intrinsic motivations to comply with the law and reducing the overall legitimacy of public regulations.

We focused on the effectiveness of TAC vis-à-vis forest conservation outcomes. In doing so we did not fully account for the educational impact of FSPs on suppliers (Gong et al., 2018), which may in the longer run influence land use practices, including pasture intensification. A longitudinal study would be needed to capture this effect.

We considered a definition of equity as non-bias, or equality of opportunity. Assessing distributional equity of outcomes poses an important counterfactual question: what would be the fate of suppliers absent the FSP? This question requires further empirical work. Accounting for dynamic and endogenous FSP locations, development of criteria, scope and market share involves many uncertainties, but is key to evaluate today's FSPs design.

7. Conclusion

FSPs are fundamental to the governance of tropical forest ecosystems that are under pressure from tropical commodities expansion. Population increase and demand for economic development and rising inequalities require commodity value chains to become more environmentally and socially sustainable. We dissect the role of cooperative enforcement in FSPs, and how this unfolds in multi-tier and heterogeneous supply chains. We present the case of TAC, a purportedly cooperative enforcement based FSP aiming to legalize the meat and cattle sectors in the Brazilian Amazon – sectors responsible for a large share of deforestation risk and resistant to change. These sectors are characterized by multi-tier, heterogeneous and unequal supply chains with differentiated motivations and abilities to comply among upstream suppliers. These sectoral features generate effectiveness-equity tradeoffs in the design of supply chain policies to tackle sustainability issues.

We show that a more cooperative model of enforcement of FSPs may in principle enable more marginal and disadvantaged suppliers to achieve compliance, thereby improving both the effectiveness of supply chain policies and their equity. However, even cooperative models of enforcement are prone to exhibit coercive tendencies in multi-tier supply chains, leading to severe equity shortcomings. Given the rapid proliferation of FSPs throughout the tropics and the relative vulnerability of farmers operating in these regions, more research is urgently needed to highlight how cooperative enforcement can be extended from first-tier suppliers upstream, to include the numerous and weaker suppliers' groups whose inclusion is key for equitable and effective outcomes.

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CRediT authorship contribution statement

Federico Cammelli: Conceptualization, Methodology, data collection, Data curation, Formal analysis, Writing – original draft, Writing – review & editing, Visualization, Funding acquisition. **Samuel A. Levy:** Methodology, data collection, Writing – review & editing, Visualization. **Janina Grabs:** Methodology, Writing – review & editing, Funding acquisition. **Judson Ferreira Valentim:** Writing – review & editing. **Rachael D. Garrett:** Methodology, Writing – review & editing, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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8 Appendix

8.1 List of acronyms in Portuguese language

Acronyms in Portuguese language	English translation
TAC	Terms of adjustment of conduct
MPF	Brazilian Public Prosecutor
CAR	Rural-Environmental Registry
GTA	cattle movement records
ADEPARA	Para' animal defense agency

Additional tables

Table A1
Overview of interviews' respondents

#	Id	Type	Municipality	Role	Interview use
1	sl_1	Tier 1: slaughterhouse	O	Legal representative	Coded
2	sl_2	Tier 1: slaughterhouse	O	Administrative director	Coded
3	sl_3	Tier 1: slaughterhouse	O	President	Coded
4	sl_4	Tier 1: slaughterhouse	O	General manager	Coded
5	sl_5	Tier 1: slaughterhouse	O	Industrial manager	Coded
6	sl_6	Tier 1: slaughterhouse	O	TAC monitoring officer	Coded
7	sl_7	Tier 1: slaughterhouse	O	President and funder	Coded
8	sl_8	Tier 1: slaughterhouse	O	Administrative director and President	Coded
9	t2p1	Tier 2 supplier (fattener)	Paragominas	Owner	Coded
10	t2p2	Tier 2 supplier (fattener)	Paragominas	Owner	Coded
11	t2p3	Tier 2 supplier (fattener)	Paragominas	Owner	Coded
12	t2p4	Tier 2 supplier (fattener)	Paragominas	Owner	Coded
13	t2p5	Tier 2 supplier (fattener)	Paragominas	Owner	Coded
14	t2p6	Tier 2 supplier (fattener)	Paragominas	Owner	Coded
15	t2p7	Tier 2 supplier (fattener)	Paragominas	Owner	Coded
16	t2p8	Tier 2 supplier (fattener)	Dom eliseu	Owner	Coded
17	t2p9	Tier 2 supplier (fattener)	Dom eliseu	Owner	Coded
18	t2p10	Tier 2 supplier (fattener)	Ipixuna	Owner	Coded
19	t2p11	Tier 2 supplier (fattener)	Ipixuna	Owner	Coded
20	t2p12	Tier 2 supplier (fattener)	Ipixuna	Owner	Coded
21	t2p13	Tier 2 supplier (fattener)	Ipixuna	Owner	Coded
22	t2p14	Tier 2 supplier (fattener)	Ipixuna	Owner	Coded
23	t2p15	Tier 2 supplier (fattener)	Ipixuna	Owner	Coded
24	t2p16	Tier 2 supplier (fattener)	Paragominas	Owner	Coded
25	t2p17	Tier 2 supplier (fattener)	Ipixuna	Owner	Coded
26	t2p18	Tier 2 supplier (fattener)	Dom eliseu	Owner	Coded
27	t3p_1	Tier 3 supplier (calver)	Paragominas	Owner	Coded
28	t3p_2	Tier 3 supplier (calver)	Paragominas	Owner	Coded
29	t3p_3	Tier 3 supplier (calver)	Ulianopolis	Owner	Coded
30	t3p_4	Tier 3 supplier (calver)	Dom eliseu	Owner	Coded
31	t3p_5	Tier 3 supplier (calver)	Dom Eliseu	Owner	Coded
32	t3p_6	Tier 3 supplier (calver)	Ipixuna	Manager	Coded
33	t3p_7	Tier 3 supplier (calver)	Ulianopolis	Owner	Coded
34	t3p_8	Tier 3 supplier (calver)	Ulianopolis	Owner	Coded
35	t3p_9	Tier 3 supplier (calver)	Ulianopolis	Manager	Coded
36	t3p_10	Tier 3 supplier (calver)	Paragominas	Owner	Coded
37	t3p_11	Tier 3 supplier (calver)	Paragominas	Owner	Coded
38	t3p_12	Tier 3 supplier (calver)	Paragominas	Manager	Coded
39	t3p_13	Tier 3 supplier (calver)	Paragominas	Owner	Coded
40	gov_1	Public prosecutor office	na	Public prosecutor	Informational
41	gov_2	Animal defense agency	Paragominas	Technician	Informational
42	gov_3	Municipal agriculture secretariat	Paragominas	Municipal inspector	Informational
43	gov_4	Municipal environmental secretariat	Paragominas	Environmental monitoring officer	Informational
44	gov_5	Municipal environmental secretariat	Ulianopolis	Environmental monitoring officer	Informational
45	un_1	Association of Brazilian exporting meat industry	na	President	Informational
46	un_2	Pará meat industry union	na	President	Informational
47	un_3	Brazilian national union of meat industry	na	President	Informational

Respondent type:

t1p	Tier 2 supplier	gov	Government agency
t2p	Tier 3 supplier	un	Producers' union
sl	Tier 1: Slaughterhouse		

Other symbols

O	Omitted for anonymization	na	Not applicable

Table A2
Respondents characteristics - Suppliers

	Tier 1- Fatteners				Tier 2 - Calvers			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Farm size (ha)	7802	10868	80	35000	515	514	45	1900
cattle herd (heads)	4716	8192	60	25000	244	280	10	930
Age respondent	42	12	28	60	57	19	2	74
Years on farm	19	12	6	47	30	15	8	61
Participate in farmer association or union	0.9	0.3	0	1	0.6	0.5	0	1
N	13				18			

Table A3
respondents' characteristics - Slaughterhouses

	TAC signatory				non TAC signatory			
	mean	sd	min	max	mean	sd	min	max
Processing capacity (heads/day)	433	204	67	600	450	o	o	o
Share of operated capacity	0.57	0.28	0.2	1	0.59	o	o	o
Rate of excluded suppliers	0.36	0.27	0.5	0.7		o	o	o
Share of operation as service provider	0.46	0.51	0	1	0.36	o	o	o
# of cattle processed as service provider	49	69	0	176	78.5	o	o	o
N	6				2			

o = omitted information to avoid identification.

Table A4
Overview of themes and cases classification structure - Farmers

Variables group	Variables
1 Respondent and property features	Municipality
	Role
	Community
	Age
	Gender
	Time on farm
	Participate in association
	Participate in church
	Farm size (ha)
	Forest area
	Cattle heads
	Produce soy
	Recently expanding property/renting area
	Goal of cattle production (dairy, calving, fattening)
2 Commercialization	Ease of commercialization
	Perceived changes with respect to the past
	Prospective changes in the future
3 Choice of buyer	Chosen buyers
	Reasons for choice of buyer - slaughterhouse
	Reasons for choice of buyer - farmer (only if tier 2)
	Constraints in the choice of buyer
	Receive price higher/lower than market price
4 Buyer engage (offers benefits and or incentives)	Presence & type of benefits or incentives offered (general)
	Presence & type of benefit or incentives offered (to comply with TAC)
5 Documents requested by buyers	Documents required by buyers
	Environmental restrictions required by buyers
	Actions undertaken to comply with TAC restrictions (if any)
	Restrictions ever changed
	Perception whether other farmers as selling to the same buyers/facing the same restrictions
6 TAC implementation (if sold to TAC signatory)	Perception that buyer monitors for compliance
	Perception that buyer excludes if non-compliant
7 Other agreements with buyers	Whether rents pasture & how much
8 public policy	Perceptions about public policies supporting farmers' compliance
9 Intrinsic values	Motivation for doing cattle ranching
10 Future plans/hopes	Vision for the future of their farm

Table A5
Overview of themes and cases classification structure - Slaughterhouses

Variables group	Variables
1 Respondent features	Name
	Gender
	Time working in slaughterhouse
	Role
2 Slaughterhouse features	TAC signatory
	Municipality
	Inspection type
	Share of volume processed as service provider
	Year of opening of plant
	Processing capacity
	Export destinations
3 Ease in finding suppliers	Share of processing capacity operated
	Ease in finding suppliers
	Sourcing radius
	Sourcing constraints
	Expected changes in sourcing in the future
4 Ease in selling meat	Ease in selling meat
5 Procurement process and TAC implementation	Whether monitors suppliers
	Criteria imposed on suppliers
	Share of suppliers excluded
	Presence & type of long term relation with suppliers
	Presence & type of benefits to secure supply
	Constraints in monitoring suppliers and achieving compliance
	Perceived impact on suppliers' behaviors
	Perceived impact on suppliers' values
5 Cooperative Enforcement	Whether & how they engage non-compliant suppliers
	Strategy to gain loyalty of suppliers after exclusion and regularization
6 Public policy	Perception that TAC implementation is supported by public policy

Table A6
TAC enforcement parameters for slaughterhouses and cattle farmers

	Slaughterhouses	Cattle farmers
Information and Participation	Voluntary participation in a negotiated agreement and disclosure of information	Automatic requirements for exclusion from the formal market. Criteria were communicated at the moment of purchase
Flexibility of criteria	Strict, but ambiguously interpreted by monitoring and auditing companies. Monitoring costs for firms relatively low.	Strict and non-negotiable criteria that are uniform across actors (with exceptions provided for in the forest code). Regularization costs might exceed small and medium farmers' capacity.
Monitoring	Based on voluntary information disclosure, evolving but unclear auditing criteria resulted in a forgiving sanctioning system (no fines in Para)	Information provided through satellite monitoring, which generates automatic market exclusion, with some mistakes, and the burden of the proof is substantial for the defense.
Sanctions	Proportional to the infraction (amount of illegal cattle that was sourced)	Uniform. The produce of the whole farm was excluded for the market regardless of the area deforested (modified in March 2020)
Regularization procedure	Continuous improvements goals based on capacity.	As per PRA (*Programa de Regularizacao Ambiental,* Environmental Regularization Program in English): more expensive the more recent is deforestation and the extent of the infraction. Not proportional to economic capacity.
Segments mostly affected	Larger and exporting slaughterhouses	Mostly finishing beef farms
Chances of evasion	Higher the smaller the company	Higher the larger the company (laundering through multiple properties, especially across states) Depends on TAC market share
Indirect costs of TAC	Unfair competition among signatories and non-signatories	Unfair competition among compliant farmers and non-compliant farmers (selling to non-signatory slaughterhouses). Increased competition in the formal sector due to increased efficiency and vertical integration that pushes less efficient farms out of the market.
Costs of compliance if criteria were extended to indirect suppliers	Increased search and monitoring costs	Larger for most small and medium calves producing farms, which are likely to have no means to comply, and for finishing farms that outsource calves
Chances of evasion if criteria were extended to indirect suppliers	Unchanged	Depends on non-TAC signatories market share

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2021.130031.

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