Title: The Club Approach: A Speedrun to stop deforestation?

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Abstract: The EU must form a forest club with trade partners to fund sustainable agriculture and limit global deforestation.

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Introduction

Deforestation and forest degradation are at the heart of two major environmental challenges in the decades to come: global warming and biodiversity loss[1–5].

This has been known for a long time now, yet large-scale political actions to tackle deforestation have stagnated until recently. On December 6th, 2022, the European Parliament reached a provisional political agreement, ensuring that a list of selected agricultural and forestry goods arriving on the EU market "*will no longer contribute to deforestation and forest degradation in the EU and elsewhere in the world*". The EU proposal highlights the obligations of European operators, expanding the scope of the current due diligence requirements, and ensuring that the risk concerning non-compliant commodities or products imported in or exported from the EU market is negligible [6].

Problematic

Unilateral action, global benefits, and country-specific costs

The proposal represents a unilateral initiative to fight against the use of forestland for agricultural production in the form of a trade ban concerning all legal and illegal deforestation. Assessing the potential repercussions of this proposal involves quantifying the agricultural-driven deforestation generated by the targeted commodities related to the global supply chains traversing or ending in the EU. Hence, we should delineate a map of the agricultural-driven deforestation embodied in international trade by first considering inter-country and inter-sector linkages [7] based on the most accurate spatial resolution of the land used [4] and second by using a new accounting method [8] that allows for tracking deforestation embodied in international trade flows throughout the world economy, with a particular focus on the EU area.

Since Brazil is a particularly significant and critical hotspot regarding deforestation [4], we shall work on a Brazilian case study. We should first assess the deforestation associated with agricultural commodity trade flows that would be covered by implementing this EU provisional political agreement per se. We then shall investigate the scope of its efficiency through a counterfactual analysis by assessing the impact of trade frictions depending on the forest content of traded goods. Consistent with the selected agricultural goods of the provisional agreement, we will apply this new regulation to the following economic sectors: oil seeds, sugar, grains other crops, cattle, and meat. We will then be able to estimate the minimum geographical scope for the trade regulation proposed to be environmentally effective. Our results highlight that without a proactive engagement of other major consumer markets, the EU provisional agreement appears to have only a marginal effect on curbing Brazilian deforestation.

Forest preservation would bring a global environmental benefit. However, since forests are concentrated in a few countries, the economic cost arising from trade regulation will be country-specific, which raises concerns about the effects of such costs in terms of economic growth expectations and equity within and between countries. To address this trade-off, we estimate the potential economic loss for Brazil and evaluate the increase in productivity needed to reach a solution in the form of an economic-environmental equilibrium.

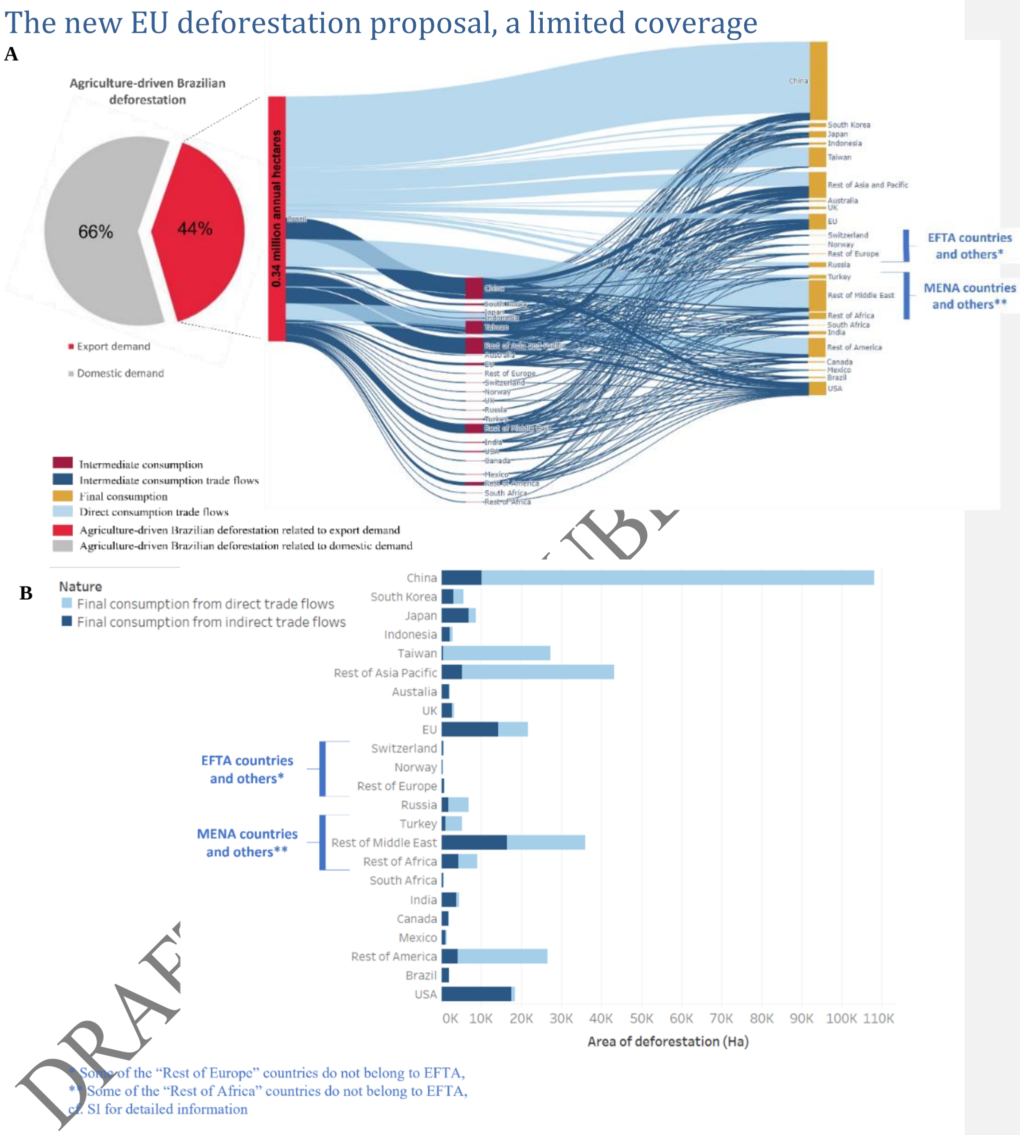

Fig. 1: **International trade flows embodying agriculture-driven Brazilian deforestation, detailed by their traversing area and their area of final consumption**. The upper panel (**A**) represents, in light blue, the direct consumption (commodities exported from Brazil to a given country and then consumed in this given country). In dark blue, the indirect consumption (commodities exported from Brazil to a given country, then transformed and re-exported in a third country where they are finally consumed). The size of the flows is proportional to the embodied agriculture-driven deforestation. The bottom panel (**B**) details the different flows from panel A by area of consumption in hectares (Ha) of agriculture-driven Brazilian deforestation.

We investigated the incremental annual deforestation for the period 2012-2019 and found a yearly agriculture-driven deforestation rate for Brazil around 0.8 million hectares per year. Furthermore, in this period, almost half of this agriculture-driven deforestation (44%) was related to agricultural goods exported and consumed outside Brazil (or embodied in trade). Our results are consistent with those of the latest study [2] extensively reviewing agriculture-driven tropical deforestation. For the period from 2011 to 2015, this work indicates an annual deforestation rate for Brazil between 0.76 and 1.5 million hectares per year for a scope of agricultural commodities consistent with the one used in our study.

At a global level, the vast majority (87%) of this agricultural-driven deforestation embodied in trade is related to direct consumption, where commodities exported from Brazil to a given country are consumed in the given country. In contrast, indirect consumption, when commodities exported from Brazil to a given country, are then transformed and re-exported in a third country where they are finally consumed, plays a minor role (13%). As illustrated in Fig. 1, significant disparities exist between the global picture and local situations. The indirect consumption is low for Taiwan (2%), China (9%) and the rest of the Middle East (11%), while it rises to above average for the EU (66%) and reaches almost the whole consumption for the USA, South Africa, Australia, and Canada (each being above 93%). In other words, almost all the Brazilian agricultural commodities that have generated legal or illegal deforestation during their production and are finally consumed in the USA have been in-between transformed and re-exported from a third country.

Regarding the traversing aspect of the supply chains in Fig. 1 and particularly traversing the EU, we can see that the three main downstream flows concern the USA, the UK, and China. The upstream role of the EU in the indirect consumption of China and the USA is relatively weak (respectively 3.8% and 3.3%) but much more important regarding the UK's indirect consumption (18.6%). Thus, any trade ban relating to the EU provisional political agreement would have a limited effect on the trade between EU-China and EU-USA. Furthermore, the role of the EU in the indirect consumption of EFTA countries is also significant (e.g., 18.9% for Switzerland and 18.7% for Norway), this argues in favor of extended geographical coverage in the future application of this provisional agreement.

The final scope of the due diligence requirements that will ultimately be chosen in the upcoming application of this EU provisional political agreement will be crucial. Regarding the geographical coverage that could be limited to the EU only or extended to the EU, the European Free Trade Association (EFTA) and the UK, but also, regarding the consumption scope, targeting only direct consumption or including also indirect consumption. Depending on these parameters, this agreement would concern between 2.4% and 7.7% of the annual agricultural-driven Brazilian deforestation embodied in trade. This constitutes between 0.95% and 3.4% of the yearly agricultural-driven Brazilian deforestation.

The EU provisional agreement on deforestation is a strong political signal, underlining the need to address global deforestation that contributes significantly to climate and biodiversity crises. On the other hand, it appears that a unilateral trade initiative's effectiveness for a global issue could be very limited.

Looking for a win-win scenario? Welcome to the club

Over the last 30 years, the understanding of climate issues has significantly evolved, resulting in continuous diplomatic conversations and various formal agreements, most notably under the United Nations Framework Convention on Climate Change (UNFCCC) and its Conference of the Parties (COP)[9]. However, despite these discussions, there has been minimal tangible action in curbing GHG emissions[10,11], revealing a gap between climate talk and actual climate action[9]. Although the current political framework around climate change struggles to promote cooperation[12], much of this challenge stems from the global public good nature of the climate change issue. As with other public goods, when everyone stands to benefit from a stable environment, nations may lean towards letting others shoulder the costs, undermining collective action[9].

Considering the dramatic increase of international collaboration required to "*prevent dangerous anthropogenic interference with the climate system*"[1] and to achieve the Paris Agreement's goals[13], a growing number of scholars, environmentalists and policy makers advocate to consider additional co-operation approaches[14]. Among them, there is an increasing enthusiasm for the club approach. It starts with clearly defined targets and conditions for members, where cooperation starts in small groups and eventually broadens, while non-members might either miss out on benefits or need to pay for them or can even be subject to different sanctions[9]. (Paroussos et al., 2019; Hovi et al., 2016; Keohane & Victor, 2016; Nordhaus, 2015[15]; Sabel & Victor, 2017).

This definition is broad and, as mentioned in Falkner et al. 2022, the club concept still needs structure and conceptual clarification. As such it is important to underline that we mention refer to the concept as "*transformational clubs*" [9], where countries with a shared purpose, aiming to alter incentives to combat the free-riding issue and enforce strict climate goals. They incentivize membership through exclusive benefits, such as trade advantages and technology access, while penalizing non-compliance with sanctions or tariffs. Initiated by like-minded nations, these clubs aim to broaden participation by offering tangible benefits. Last, the academic focus increasing enthusiasm for the creation of climate clubs (e.g., Victor, 2011; Weischer et al., 2012; Hovi et al., 2019; Falkner, 2016; Keohane et al., 2017; Green & Rudyk, 2020; Pihl, 2020; Falkner et al., 2022) has been mainly focus on the creation of climate club.

Based on this description of the situation, two key elements are necessary to investigatre. The forest nature and the political difficulty of the transformational cub. To our knowledge, it is the first time that the club hypothesis has been tested for a deforestation issue rather than a climate issue. The transformational club model for climate policy demands nations to adopt binding rules and punitive measures against non-compliance. Despite its logical appeal in addressing free-riding, its stringent nature based on economic theories makes it politically challenging to realize. Historical observations indicate a preference for voluntary pledges with international review mechanisms, like the Paris Agreement, due to inherent distributional conflicts. While a transformational club might be feasible among aligned countries, like the US and EU, with discussions around joint carbon pricing and tariffs, it would need to involve major emitters like China, India, and Russia to be truly effective. Although the US-EU collaboration represents a significant global GDP percentage, such an approach poses concerns, including the need for a robust legislative framework, potential WTO challenges, trade retaliations, and equity issues related to differentiated responsibilities. The stringency that makes transformational clubs

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appealing is also its biggest obstacle, potentially jeopardizing the existing multilateral climate framework.

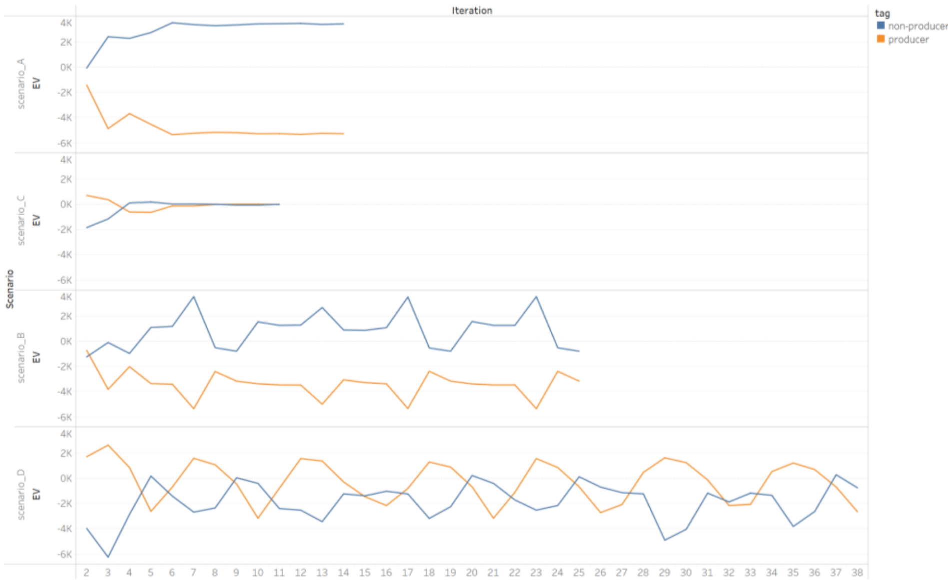
This issue crystallizes the remaining reserves of academics regarding the club idea, where several of them underline their perfect theoretical framework but highlight their international legitimacy deficit and thus consider them as useless object to solve any environmental challenge. Here, the findings of Morin et al., 2023 are particularly relevant, as they show that they reveal that global environmental governance has been producing club benefits for years, even though they weren't recognized as such. Their article focusses primarily on International Environmental Agreements (IEAs) but it appears that previous academic studies might have exaggerated or placed too much emphasis on how World Trade Organization (WTO) agreements discourage or limit the use of trade-related provisions in environmental governance. Last, their findings show that the formation of such clubs might not necessarily start from scratch, as proposed by Nordhaus (2015). Instead, these clubs can gradually develop from pre-existing institutions[16].

Based on this, we design a counterfactual scenario

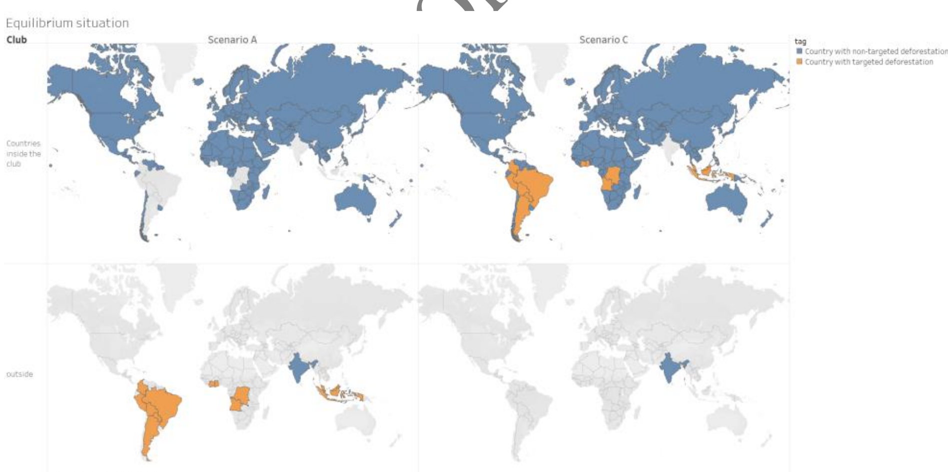
To this end, we first design a counterfactual scenario where trade frictions are introduced by the EU on worldwide agricultural commodities causing tropical deforestation (following the same scope that the EU due diligence on deforestation). For each country where the tropical deforestation occur, those trade frictions implemented by the EU via tariffs

by all countries on Brazilian exports to set the annual increase of Brazilian forestland used to produce the target commodity at zero. Second, we simulate the impact on the Brazilian economy and land use. Based on the climate-club idea proposed originally by the economist William Nordhaus in 2015 9, we use a similar approach (but not identical as greenhouse gas emissions and deforestation are different externalities by nature) and we assume a different degree of country participation in the deforestation policy. We then investigate feasible alternative policy options to avoid deforestation.

Scenario	**Countries having access to the club**	**Club countries imposing tariffs on producer countries outside of the club**	**Club countries imposing tariffs on non-producer countries outside of the club**	**Transfer to producer countries inside the club**
A	**Restricted**: Non-producer countries only	All countries inside the club	EU27	No
B			All countries inside the club	
C	**Open**: All countries (producer and non-producer countries)		EU27	Yes. Productivity Increase and decrease of q0 by a percentage that sets the annual increase in forestland use for target commodities at zero.
D			All countries inside the club	



The trend of sum of EV for Iteration broken down by Scenario. Color shows details about tag. The view is filtered on Iteration, which excludes 1.



Map based on Longitude (generated) and Latitude (generated) broken down by Scenario vs. Club. Color shows details about tag. Details are shown for Country.

It appears that, globally, a raise of agricultural productivity induces a reduction of deforestation.

implement these reductions to maintain open trade with the European Unio

The concept of a "climate club" was introduced by researchers as an attempt to ensure progress in achieving the Paris goals through the adoption of more ambitious targets and restrictive measures, including carbon pricing, by a group of countries, preferably responsible for a large share of global greenhouse gas emissions. Theoretical models are practically infeasible, so attempts have been made to develop club configurations that would take into account political, economic, and institutional realities. Based on this body of work, the first club concepts were officially presented. They differ in terms of membership conditions, policy harmonization levels, ambition of goals, and ways of penalizing non-joiners. Attempts to take into account the interests of countries with varying levels of development and elaboration of climate policy, as well as a willingness to introduce new restrictive measures, lead to a weakening of the institutional structure and a reduction in efficiency. However, in some aspects, cooperation can still develop to ensure emission reductions. The main such aspect, apparently, will be the harmonization of standards.

Establishing partnerships for implementing shared ambitions. This interaction component includes capacity-building, technology transfer and exchange, financing issues, particularly relevant and essential for developing countries.
Addressing issues arising from policy differences. Each club member will have its set of decarbonization measures; serious harmonization in this area cannot be expected. Therefore, the club's second pillar deals with issues and disagreements arising from policy differences. Collaboration on carbon adjustments and ensuring various measures meet WTO standards will be the main focus of the second pillar. This interaction aspect is especially crucial for the EU and those countries willing to strengthen climate regulation but will strive to solve the freeloader problem, particularly leakages.
Ensuring harmonization at individual sector levels. The club's third pillar involves developing uniform standards for specific industries, preferably the most carbon-intensive and simultaneously at risk of leakage. Unified standards can simplify international trade among members. Developed countries, especially the EU with its intricately designed and branched system of product requirements in the market regardless of origin, can guarantee the use of their technologies as the most advanced. Developing countries might see an increase in investments into their enterprises for technology production on their territory due to the introduction of such standards.
Membership in the club should be determined by a willingness to accept specific quantitative ambitious goals for decarbonizing the economy. In addition to the G7 members, it's essential to include major emitters, including China and India. However, in line with the inclusivity principle, the report's authors are open to including all those willing and ready to cooperate, without evaluating their contribution to overall emissions.

Thus, the idea of establishing a climate club solely by the G7 members initially didn't make much sense. They couldn't transition from the idea to club creation within a year, reach an internal consensus, and persuade other partners. However, they didn't abandon the idea but shifted its development and promotion to outreach formats, primarily at the expert community level, including T7 and T20. Considering the sequence of presidencies of developing countries in the "G20", their role and influence on the club's agenda and configuration might become decisive if it's developed based on unification.

Commented [EB1]: Early draft

Beyond those interesting results, is this approach

An International Forest Club Fund to leave the deforestation dilemma

Commented [EB2]: dRaft

The word "*kairos*" is an ancient Greek word, usually understood as the "due time" to act. The climate, biodiversity, and global deforestation crises are all reaching tipping points regarding absolute sustainability thresholds. They are all facing their *kairos*, as there is no time left for a delay. For the ancient Greek philosopher Isocrates, recognizing the *kairotic* timing is an essential attribute of the political action. In this sense, the EU fully embraces its political institutional role, considering the necessity and the emergency to act against global deforestation. However, *kairos* is originally a more complex and flexible word that also refers to the implicit sense of right measure or "due measure"[17]. Under this aspect, we have seen that although the EU initiative about global deforestation is an important political signal, its effectiveness will be limited unless big trade players take the chance to join the EU.

Because of the non-uniform spatial distribution of forests, the forest preservation cost arising from import regulations would be unevenly distributed across countries. To tackle global deforestation and to escape this prisoner's dilemma, the EU needs to favor the diplomatic path along with acting unilaterally.

First, as the main forests and biodiversity hotspots are in low- and middle-income countries, convincing them to accept trade constraints on forestland can be challenging as they consider them a strong limit to their economic growth. The EU already faced a similar issue in the Carbon Border Adjustment Mechanism (CBAM) case. Several studies [18–20] highlight that international cooperation is needed to mitigate the adverse effects for low-income countries. Similarly, in the case of Brazil, our analysis shows that an increase in the total factor productivity can counterbalance the negative economic impact of introducing trade policies against deforestation.

Convincing some trade partners to form a *forest club* (for instance, China and MENA countries in our Brazilian study case) to create an International Forest Club Fund (IFCF) would alleviate several problems, including the amount of finance provided by high-income countries to low- and middle-income countries to limit deforestation without compromising economic growth goals. With a trade policy on deforestation coordinated between members, the IFCF will reduce the *forest footprint* and channel financial resources to enhance productivity in agriculture production in countries where forest resources are relevant.

Creating such a club rather than an international organization or a Conference of the Parties (COP) can help reach a consensus in environmental negotiations and bypass the unanimity issue. On the importing side, it is shown that a rather small club would effectively fight deforestation. On the exporting side, it is shown that supporting innovation in crop productivity would be a feasible target making such a collaboration a win-win scenario.

To all, this is added to the election of the new Brazilian president Luiz Inácio Lula da Silva who has recently declared that Brazil will "do whatever it takes to have zero deforestation and degradation of [its] biomes". The *kairos* also has a temporal sense, and the EU could not hope for a better timing for action!

https://environment.ec.europa.eu/topics/forests/deforestation/regulation-deforestation-free-products_en

https://blogs.worldbank.org/developmenttalk/can-agricultural-productivity-save-amazon

Following the normative frameworks defined in the report "*Cooperation and Implementation of Climate Actions through the Climate Club*" as an independent report for the G7[21], we exactly framed our club proposal in the same way:

Dissatisfaction with the multilateral approach[22] combining a minilateral club to increase the climate policy ambition. What could a club approach hope to achieve, and what do we know about its political feasibility and desirability? *Clubs aimed at negotiating targets and measures can increase bargaining efficiency, but struggle to deal with equity and distributional conflicts* [22].
Clubs seeking to change incentives via club benefits and sanctions face the highest hurdles to implementation. Their promise to tackle free-riding remains untested and difficult to achieve
Once the decision of the rules of the clubs are implemented, we build a Nash equilibrium model to determine if regions would join this club or not based on their welfare.

Research shows that, globally, raising agricultural productivity reduces deforestation. In Brazil, labor productivity growth in agriculture has grown faster than in all other sectors over the last 25 years (figure 1)

Lack of Global Authority: There's no global governing body to oversee climate change mitigation. The Paris process might eventually establish such an authority.

The creation of cub regarding tropical deforestation, despite presenting some similar structure to the climate change issue presnrt some particular aspects that may facilitate the

Global public goods are most easily provided when a single dominant country, or a small group, takes the lead6,7,13 •

Method

Our assessment of the Brazilian agriculture-driven deforestation embodied in international trade is based on the HIstoric Land Dynamics Assessment + (HILDA+) global dataset [4] and, more particularly, the transitions between land categories. Compared to the existing sources that can vary significantly in their estimation of Brazilian agriculture-driven deforestation [2], the novelty of this dataset is to fully account for the different land transitions between land use/cover (LUC) categories that occur during a given period, which is an essential requirement to identify the land use dynamics and their related environmental impacts [23].

The HILDA+ dataset is defined as a 1 × 1 km grid cell resolution spanning the year 1960 to 2019. In this study, we focused specifically on the grid cells related to Brazil's geographical territory for the period of 2012 to 2019. This specific time frame was chosen as HILDA+ does not contain data beyond 2019 and because the inclusion of data prior to 2012 could potentially skew the analysis due to the influence of the 2008-2009 global financial crisis on world trade. Then, among all the different LUC categories, we focused on the specific LUC category changes related to the loss of forest and the gain of pasture or cropland. By doing so, we can obtain the total annual area deforested for these two categories in Brazil during the analysed period.

Several studies link deforestation to agricultural and forestry production, trade and consumption using environmentally extended Multi-Regional Input Output (MRIO) data [1,5]. MRIO tables are commonly used to identify externalities generated directly and indirectly for supplying commodities to final consumers [24–27]. In line with this literature, we use data on inter-country inter-sector linkages based on the MRIO EXIOBASE [28]. We extend EXIOBASE dataset with the HILDA+ data previously scoped to calculate the agriculture-driven deforestation embodied in international trade originating from Brazil.

However, the agricultural economic sectors represented in EXIOBASE are more detailed than the two categories (cropland and pasture) provided in HILDA+. To integrate HILDA+ data into EXIOBASE, we allocate the calculated deforestation to the different EXIOBASE economic sectors. This was accomplished by utilizing data from the Food and Agriculture Organization of the United Nations (FAO), which indicates the annual surface area used for each type of agricultural commodity cultivated in Brazil as well as the annual number of heads of livestock in Brazil. The mapping between the FAO data and the EXIOBASE economic sectors is indicated in Table S1.

Then, considering the n different years in our study, for a year c, an FAO commodity i, an EXIOBASE economic sector j and a HILDA+ category s, we used the annual occupied area (A) and the annual deforestation area (D) to calculate the average deforestation area over the period per EXIOBASE economic sector by using equations (1) to (3).

$$\boldsymbol{G_{c,j}} = \begin{cases} \sum_{i \in \boldsymbol{j}} (A_{c,i} - A_{c-1,i}), & \sum_{i \in \boldsymbol{j}} (A_{c,i} - A_{c-1,i}) > 0 \\ \boldsymbol{0}, & \sum_{i \in \boldsymbol{j}} (A_{c,i} - A_{c-1,i}) \leq 0 \end{cases} \quad \textbf{(1)}$$

$$\boldsymbol{D_{c,j \in s}} = \frac{\boldsymbol{G_{c,j}}}{\sum_j \boldsymbol{G_{c,j}}} * \boldsymbol{D_{c,s}} \quad \textbf{(2)}$$

$$\boldsymbol{\bar{D}_j} = \frac{1}{n} * \sum_{c}^{n} \boldsymbol{D_{c,j}} \quad \textbf{(3)}$$

Where:

- $\boldsymbol{G_{c,j}}$ represents the annual evolution area occupied by an EXIOBASE economic sector *j* as the sum of the yearly evolution area of its related commodities. If the surface occupied by this economic sector has annually decreased, then $\boldsymbol{G_{c,j}}$ is equal to 0 for this year,
- $\boldsymbol{D_{c,j \in s}}$ represents the annual repartition per EXIOBASE economic sector of the annual deforestation area calculated from HILDA+ ($\boldsymbol{D_{c,s}}$). For one given year, only the EXIOBASE economic sectors that have followed a positive annual evolution of the area occupied are included in the repartition, thus avoiding attributing deforestation to an EXIOBASE economic sector that would not have contributed to this deforestation,
- Finally, $\boldsymbol{\bar{D}_j}$ is the average annual deforestation per EXIOBASE economic sector. It is calculated by taking the sum of the deforestation area per economic sector calculated for the period and dividing it by the total number of years (*n*) in this study, thus smoothing out the potential variations of the deforestation area over the period for each EXIOBASE economic sector

We then apply a novel accounting method, the Throughflow Based Accounting [8], to comprehensively quantify the agriculture-driven Brazilian deforestation embodied in international trade passing through or ending in each country/area defined in EXIOBASE. We then calculate the direct consumption (commodities exported from Brazil to a given country and then consumed in this given country) and the indirect consumption (commodities exported from Brazil to a given country, then transformed and reexported in a third country where they are finally consumed) at the country level (main text, Figure 1) and at the sector level (Table S2).

Based on those EXIOBASE results, we performed a counterfactual analysis by using the Global Trade Analysis Project (GTAP) model, a perfectly competitive computable general equilibrium (CGE) model extensively used in the literature to evaluate potential policy impacts (see supplementary text for further information).

We integrate the HILDA+ previously calculated into GTAP. First, we map the EXIOBASE economic sectors with the GTAP economic sectors. Thanks to a close economic sectors definition, the mapping is straightforward with a 1:1 mapping. Then to perform the counterfactual analysis, we calculate a forest intensity coefficient (*F*) for each GTAP sector *h*, following equation (4):

$$\boldsymbol{F_h} = \left(\frac{1}{n} * \sum_{c}^{n} \frac{\boldsymbol{D_{c,h}}}{\boldsymbol{G_{c,h}}}\right) * 100 \quad \textbf{(4)}$$

Where:

- $\boldsymbol{F_h}$ represents the forest intensity coefficient for a GTAP economic sector h. Due to the 1:1 mapping between EXIOBASE economic sectors and GTAP economic sectors $\boldsymbol{D_{c,h}} = \boldsymbol{D_{c,j}}$ and $\boldsymbol{G_{c,h}} = \boldsymbol{G_{c,j}}$

The counterfactual analysis follows three main steps (summarized on figure S1). First, we set targets for land use reduction in exports using the average incremental deforestation on land use by sector for the period 2012-2019. Second, we estimate the level of tariffs preventing trade on goods embodying deforestation. These increases in trade costs, if applied by all countries in the world, meet the target in the first step. Third, we conduct the counterfactual economic analysis by applying tariffs following a sequential country-participation scheme. The rest of this section explains each of these steps.

In our simulation exercise, the objective function is to set the annual increase of Brazilian forestland used in agricultural production at zero. To achieve this goal, we design a counterfactual scenario where trade frictions are introduced on specific agricultural commodities based on the forest intensity in their exports. Specifically, the share of incremental deforestation on the total land usage by sector (average for the period 2012-2019) was used to set targets for land use reduction in exports at the sector level. Global tariffs (the most transparent trade policy measure) were then applied to Brazilian exports to obtain those reductions. These tariffs were calculated to prevent further deforestation related to trade. The global deforestation-free tariffs are shown in figure S2. Last, to avoid countervailing effects that could arise from the domestic demand on those goods which are less exported because of the newly applied tariffs, we simultaneously impose a domestic tax on the use of forest-intensive intermediates.

Our simulation is comparative static (e.g., simulation presents not changes through time, but differences between different possible states of the global economy - a base case and a policy case - at a fixed point in time) with a short-run closure: fixed (exogenous) factor endowments and endogenous factor prices. One implication is that the introduced distortions increase relative prices for land in the hit sectors with the effect of decreasing the competitiveness of forest-intensive production.

We then proceed by estimating the impacts of the deforestation trade policy by using different degrees of participation: (1) the EU, UK, and European Free Trade Association (EFTA) countries apply the regulation (*Club 1*); (2) *Club 1* plus the USA (*Club 2*); (3) *Club 2* plus China

(*Club 3*); (4) *Club 3* plus Middle Eastern and North African (MENA) countries (*Club 4*); (5) worldwide participation (*Club 5*).

For each scenario, we first estimate the likely decrease in land use and the impact on the Brazilian GDP. By construction, the *Club 5* scenario realizes the complete reduction in land use to eliminate additional deforestation linked to trade. All other scenarios represent different degrees of effectiveness in reducing land use (see discussion in the main text). The distortions introduced through the increase in trade costs bring a contraction in Brazilian exports and, although to a lesser extent in production. This is reflected in losses in terms of GDP.

We finally investigate a mechanism that would allow to compensate for the economic "damage" to countries subjected to the mitigation policy. We then focus on the increase in productivity that would allow the same level of production but avoiding further pressure on land. Productivity is typically exogenous in the model; however, it can be endogenized in order to capture the effect on a previously endogenous variable. To estimate the increase in productivity required to compensate for the loss in GDP, we set the GDP and allow a total factor productivity (TFP) shifter to be endogenously determined while imposing the increase in trade costs.

Considering the recent trends in Brazil's TFP growth rate (ranging from around 6% in agriculture and 3% for livestock, [29], the results we obtain suggest that there are indeed feasible policy options to realize a win-win scenario. When international cooperation works, global environmental benefits can be achieved with an economically neutral impact.

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