Trade and Trees

Bård Harstad

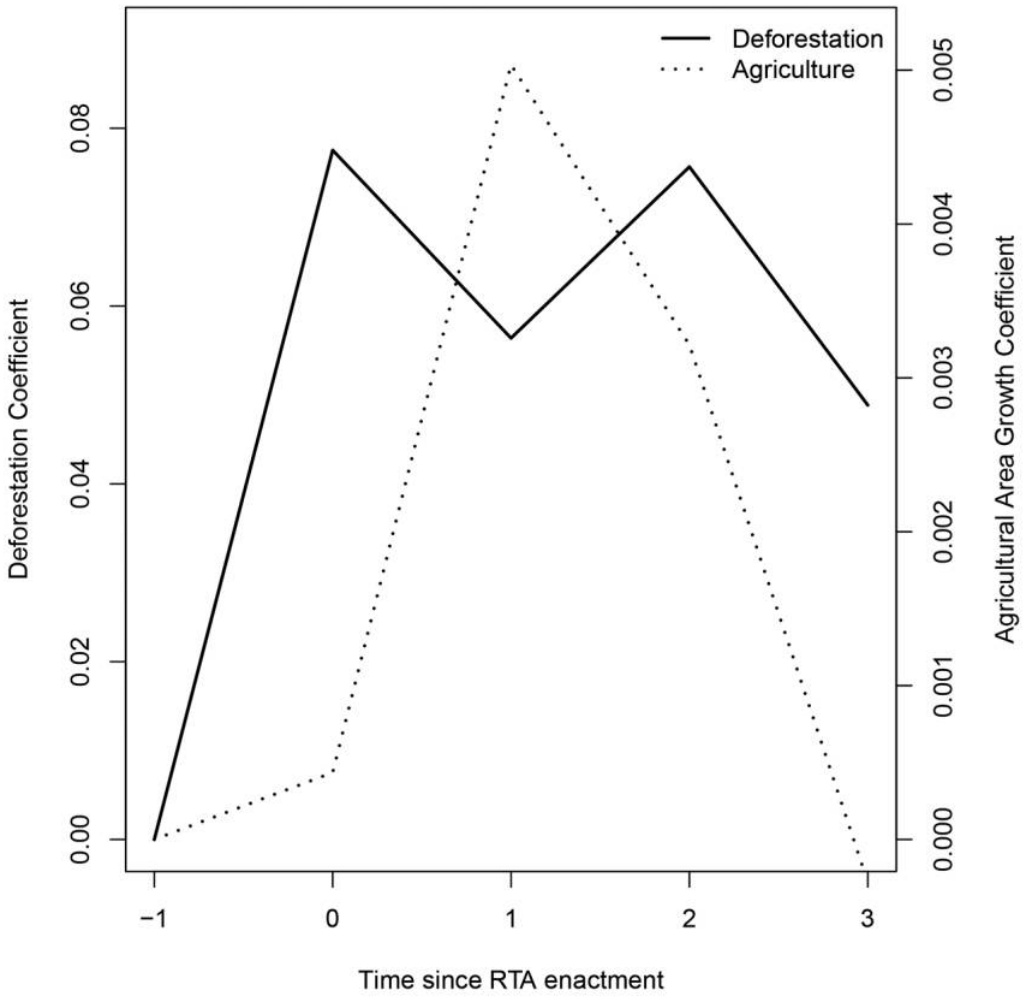
AER: Insights 6(2): 155-75.

2024

Trade vs. the Environment

- **Clashes** between proponents of trade and environmentalists have a long tradition:
  1. Seattle 1999
  2. TTIP 2016
  3. EU-Mercosur 2019-2024...
- **Intuition**: With a larger market, trees are logged, land is burned, cattle enters, soy is planted.
- Empirically, deforestation has increased when regional trade agreements have been signed (Faria et al., 2016; Pendrill et al., 2019; Abman and Lundberg, 2020).

Trade vs. the Environment



Source: Abman and Lundberg (2020)

The EU and TSD

- France and the Netherlands: In a recent "non-paper" (May 2020), they point to: "*The lack of progress in compliance with... the Trade and Sustainable Development (TSD) Chapters.*"
- They recommend that the implementation of trade agreements should proceed step-wise and hinge on the gradual implementation of sustainability requirements:
- "*Parties should introduce, where relevant, staged implementation of tariff reduction linked to the effective implementation of TSD provisions and clarify what conditions countries are expected to meet for these reductions, including the possibility of withdrawal of those specific tariff lines in the event of a breach of those provisions.*"

Questions and Outline

1. Can trade cause deforestation? Or deforestation cause trade?
2. How can trade motivate conservation?
3. Can we evaluate the proposal by France and the Netherlands?

A Model of Trees

- *The South* (S): Remaining stock is R_t and $X_t = R_0 - R_t$ is exploited.
- When S exploits $x_t \in [0, R_t]$,

$$R_{t+1} = R_t - x_t \text{ and } X_{t+1} = X_t + x_t.$$

- $\underline{a} \geq 0$ represents the marginal (present-discounted) agricultural value of the produce (beef) from X_t.
- $\underline{b} \geq 0$ is S's marginal benefit of x_t (timber)
- c is S's marginal physical/environmental cost of exploitation.
- $\delta \in (0, 1)$ is the discount factor.
- In autarky, S conserves iff

$$\underline{a} + \underline{b} \leq c.$$

A Model of Trade

- $d > 0$ is the damage to the North's (N) when a unit is logged.
- $\overline{a} \geq \underline{a}$ is N's present-discounted value of consuming a unit of S's agric produce every future period.
- $\overline{b} \geq \underline{b}$ is N's marginal benefit from the timber.
- The seller sets the price, so S can charge $\overline{a}$ and $\overline{b}$.
- $e > 0$ is N's profit from getting access to S's market.
- It is simple to endogenize e.
  - For the set of goods that N can export, S's willingness to pay ($\overline{e}$) may be larger than N's willingness to pay ($\underline{e}$). Because the seller captures the gains from trade, N's flow payoff is $u_N^{AUT}(R_t, x_t) = (1-\delta)\,\underline{e} - dx_t$ in autarky and $u_N^{FTA}(R_t, x_t) = (1-\delta)\,\overline{e} - dx_t$ with free trade. Hence, N earns $e \equiv \overline{e} - \underline{e} \geq 0$ from exporting when trade is liberalized
- A numeraire good (cookies) is used as currency.

A Model of Trade & Trees

1. At each $t \in \{1, ...\}$, the countries first decide whether to open up for trade. If they do, they can use side transfers.
   Let $\alpha \in [0, 1]$ measure S's share of the bargaining surplus.
2. S decides on $x_t \in [0, R_t]$.
3. Trade and consumption take place.

- *The First Best* is simply that the parties trade, and, if $\overline{a} + \overline{b} < c + d$, S conserves in every period.
- Equilibrium: SPE vs. MPE.
  - The below inefficiency results (Propositions 1–3) hold for *all* subgame-perfect equilibria (SPEs).
  - The efficiency result in Section IV holds *despite* the restriction to Markov-perfect equilibria (MPEs), where strategies only depend on R_t.
  - It is common to focus on MPEs given the importance of this stock.

FTA Causes Depletion

The *First Best* is unainattainable as an SPE.

Proposition

FTA: S exploits if

$$c < \overline{a} + \overline{b}.$$

Autarky: S exploits if

$$c < \underline{a} + \underline{b}.$$

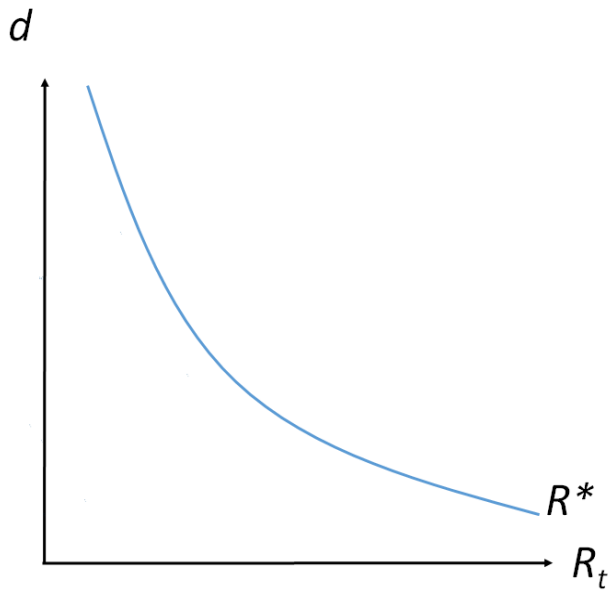
For all $c \in \left[\underline{a} + \underline{b}, \overline{a} + \overline{b}\right)$*, there is exploitation with FTA but not in autarky.*

Depletion Causes Trade

Proposition

Suppose trade influences x_t, i.e., $\underline{a} + \underline{b} < c < \overline{a} + \overline{b}$. The social value of the FTA is positive if the gains from trade are large and R_t is small, i.e., if:

$$R_t \leq R^* \equiv \frac{e + (\overline{a} - \underline{a})\, R_0}{c + d - \underline{a} - \overline{b}}.$$

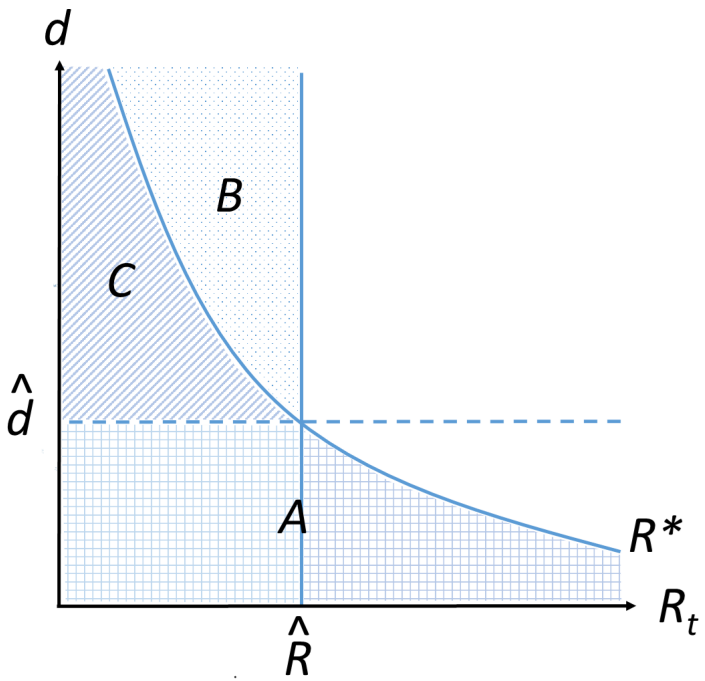


Deplete to Trade

Proposition

This second best is unattainable as an SPE: If $R_t < \widehat{R}$, or the gains from trade are large, S is willing to deplete in order to obtain an FTA. I.e., if:

$$R_t < \widehat{R} \equiv \delta\alpha \frac{e + (\overline{a} - \underline{a})\, R_0}{c - \underline{b} - \underline{a}} \text{ or } \underline{a} + \underline{b} > c.$$



FTA: Equilibrium

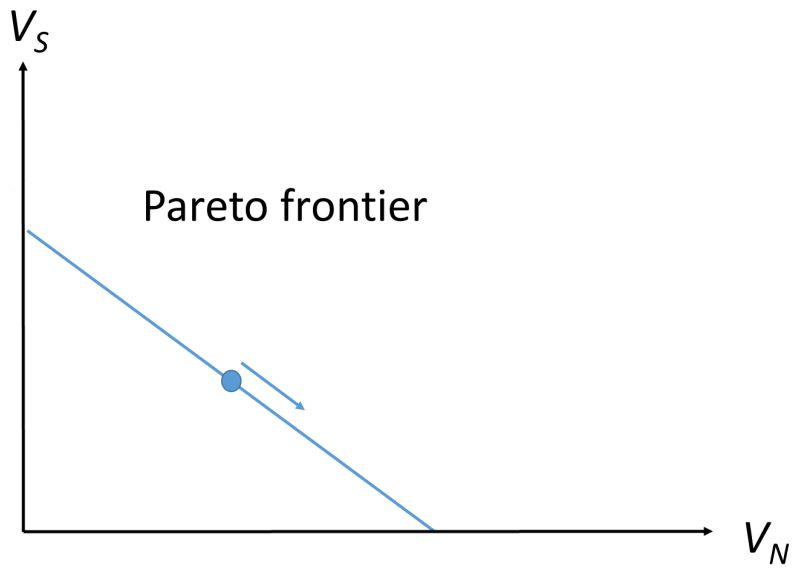
Proposition

There is a unique pure-strategy MPE: The FTA is signed, and S depletes, if and only if the gains from trade are large or R_t is small. I.e., if:

$$R_t < R^*, \text{ and then } x^D = 0, \quad \text{when } d \leq \widehat{d}, \text{ and}$$
$$R_t < \widehat{R}, \text{ and then } x^D = \phi R_t, \text{ when } d > \widehat{d}, \text{ where}$$
$$\widehat{d} \equiv \left(\frac{1}{\delta\alpha} - 1\right)(c - \underline{b} - \underline{a}) + \overline{b} - \underline{b}, \; \phi \equiv \frac{d - \widehat{d}}{c + d - \overline{b} - \underline{a} + \frac{\overline{b} - \underline{b}}{1 - \delta}}.$$

- Why is the default extraction fraction $\phi \in (0, 1)$?
  - If $\phi = 0$, N requests large compensations for the FTA if R_t is large, so S prefers to deplete first ($\phi \uparrow$).
  - If $\phi = 1$, S's bargaining position is large, S obtains an attractive FTA, and S prefers to conserve ($\phi \downarrow$) while waiting for it (Harstad, 2016).

FTA: Equilibrium



- There are multiple Pareto optimal trade agreements.
- If S faces tariff τ_S on beef, S must reduce the price. S loses, N gains.
- If N faces tariff τ_S, N must reduce the price, and S obtains revenues. Combined, the transfer to S is:

$$\overline{\tau} \equiv \tau_S e - \tau_S \overline{a} X_t.$$

FTA: Equilibrium

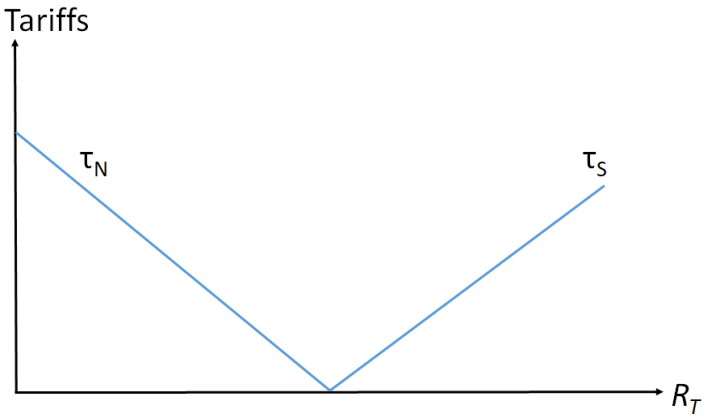


Figure:

If R_T is larger, S benefits more from trade, and N less. With bargaining, $\overline{\tau} \downarrow$.

Proposition

With an FTA signed at time T, τ_S is smaller or τ_S is larger if R_T is large:

$$\overline{\tau} = \alpha e - (1-\alpha)\Delta_a R_0 - R_T \left\{ \begin{array}{c} \alpha d - (1-\alpha)\left(c - \underline{a} - \overline{b}\right) \text{ if } \phi < 0 \\ \overline{b} - \underline{b} + \left[c - \underline{b} - \underline{a}\right]\left(\frac{1}{\delta} - 1\right) \text{ if } \phi \in [0,1] \\ \left(\overline{b} - \underline{b}\right)(1-\alpha) \text{ if } \phi > 1 \end{array} \right\}.$$

FTA: Summary

FTA

(1) $R^{FTA} \leq R^{AUT}$

(2) More valuable if R small

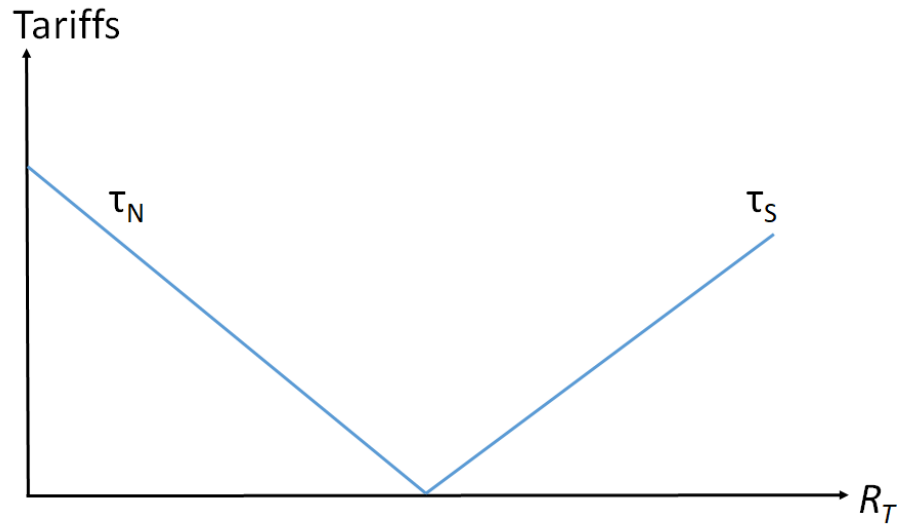
(3) Deplete to trade

(4) $x \uparrow$ if $e \uparrow$ or $R \downarrow$

(5) $\tau_S'(R) \leq 0 \leq \tau_S'(R)$

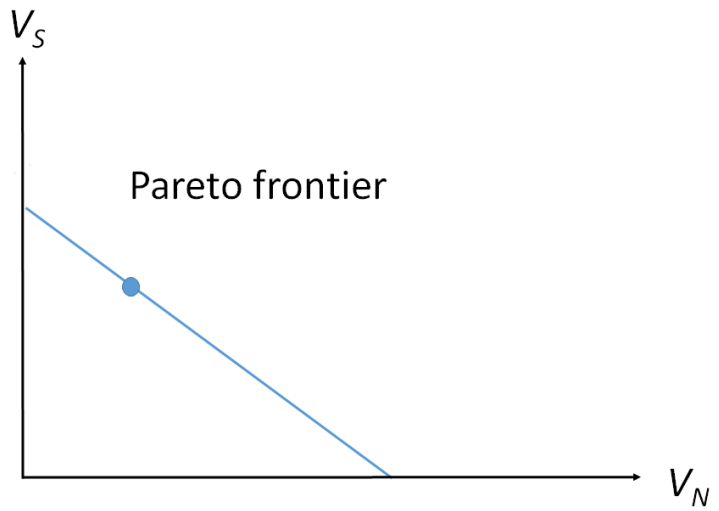
(6) Inefficient

Renegotiation-Proof Agreements



- In equilibrium, τ_S is smaller or τ_S is larger if R_T is large.
- This holds also when $t > T$, even if $R_t \neq R_T$, because the allocation continues to be on the Pareto frontier.

Renegotiation-Proof Agreements



- Any allocation on the Pareto frontier is renegotiation proof.
- In principle, the allocation does not need to be fixed once and for all.

Contingent Trade Agreement

DEFINITION: *A* CTA, *negotiated at time* T, *specifies tariffs* $\tau_S(R_t)$ *and* $\tau_S(R_t)$, *that are continent on the current* R_t *(as well as on* R_T*) unless the parties agree on different tariffs.*

FTA

(1) $R^{FTA} \leq R^{AUT}$

(2) More valuable if R small

(3) Deplete to trade

(4) $x \uparrow$ if $e \uparrow$ or $R \downarrow$

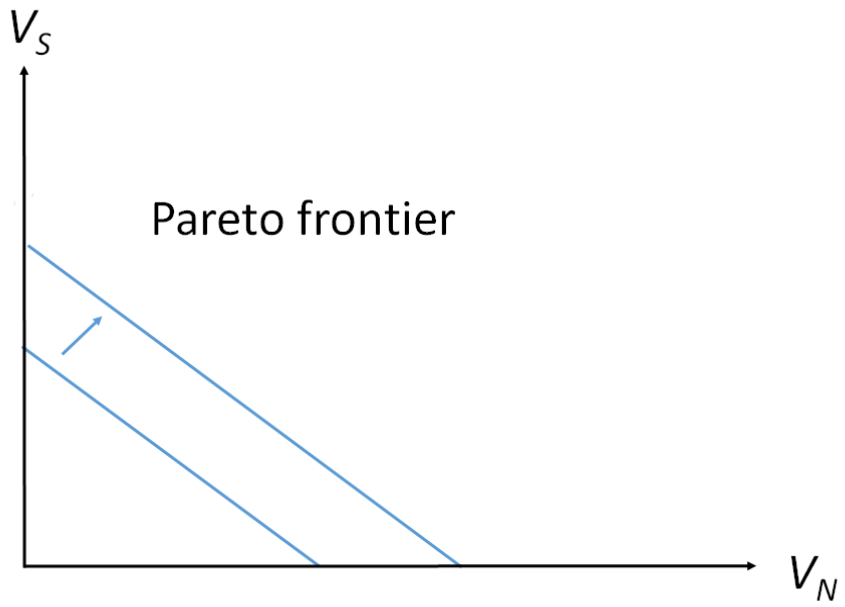
(5) $\tau'_N(R) \leq 0 \leq \tau'_S(R)$

(6) Inefficient

FTA vs. CTA

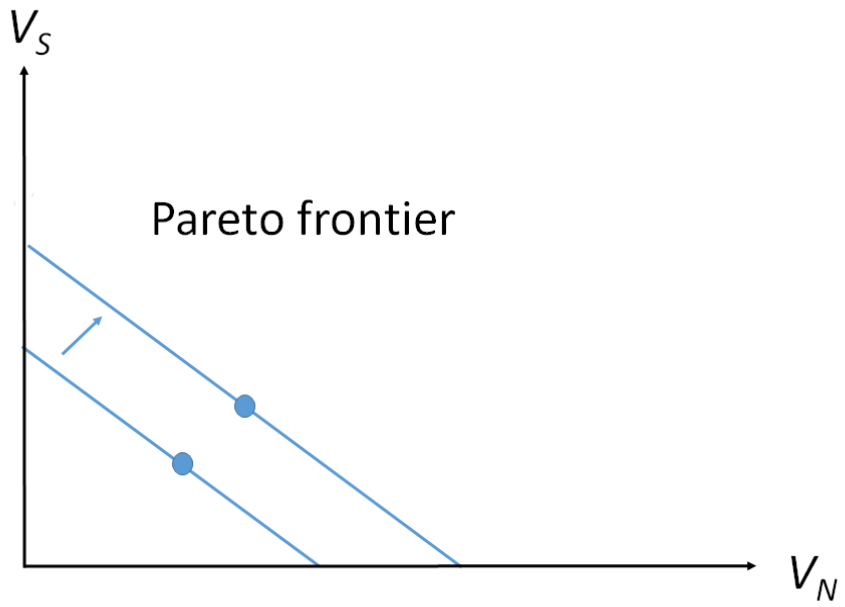
	FTA	**CTA**
(1)	$R^{FTA} \leq R^{AUT}$	$R^{CTA} \geq R^{AUT}$
(2)	More valuable if R small	More valuable if R large
(3)	Deplete to trade	Conserve for terms of trade
(4)	$x \uparrow$ if $e \uparrow$ or $R \downarrow$	$x \downarrow$ if $e \uparrow$ or $R \downarrow$
(5)	$\tau'_N(R) \leq 0 \leq \tau'_S(R)$	$\tau'_N(R) \geq 0 \geq \tau'_S(R)$
(6)	Inefficient	Efficient

CTA: Feasibility



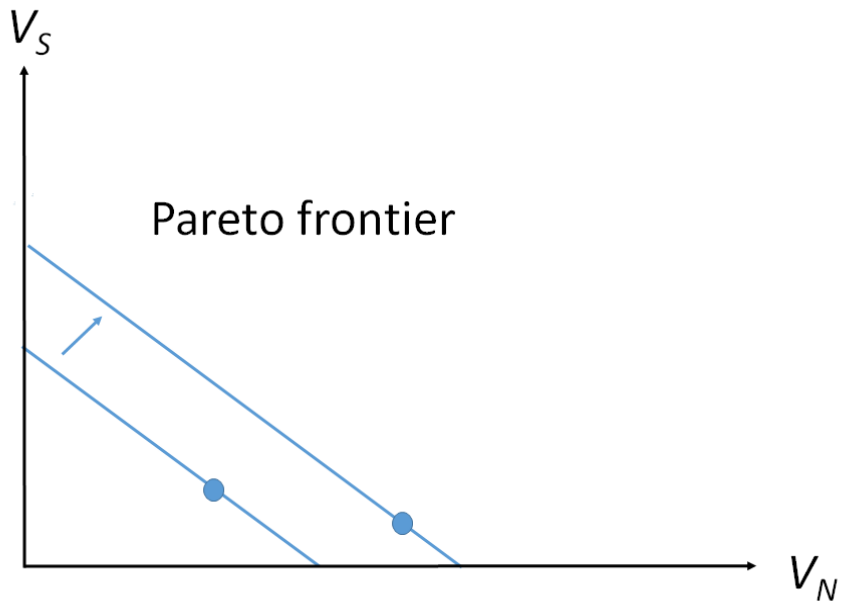
- If R_t is reduced, the gains from trade increases.

CTA: Feasibility



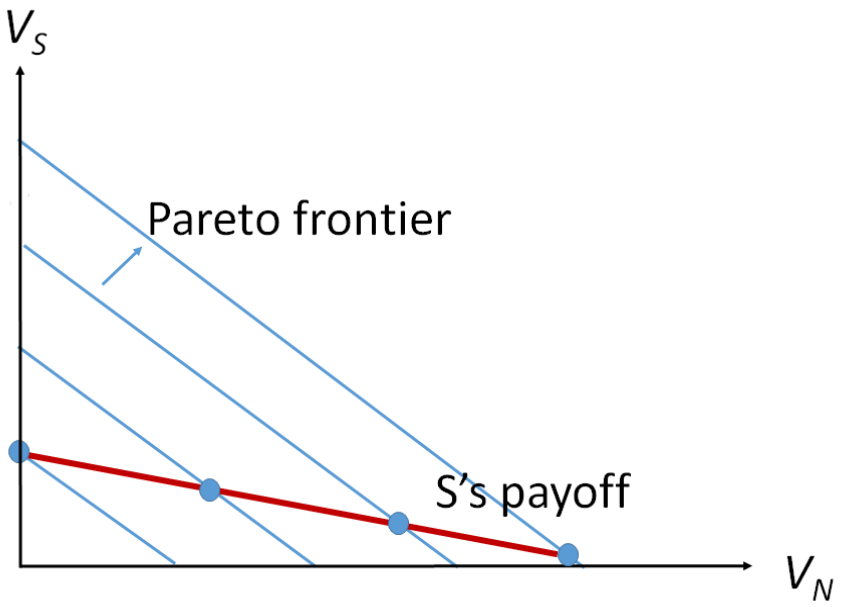
- If S obtains some of these gains, S benefits from depletion.

CTA: Feasibility



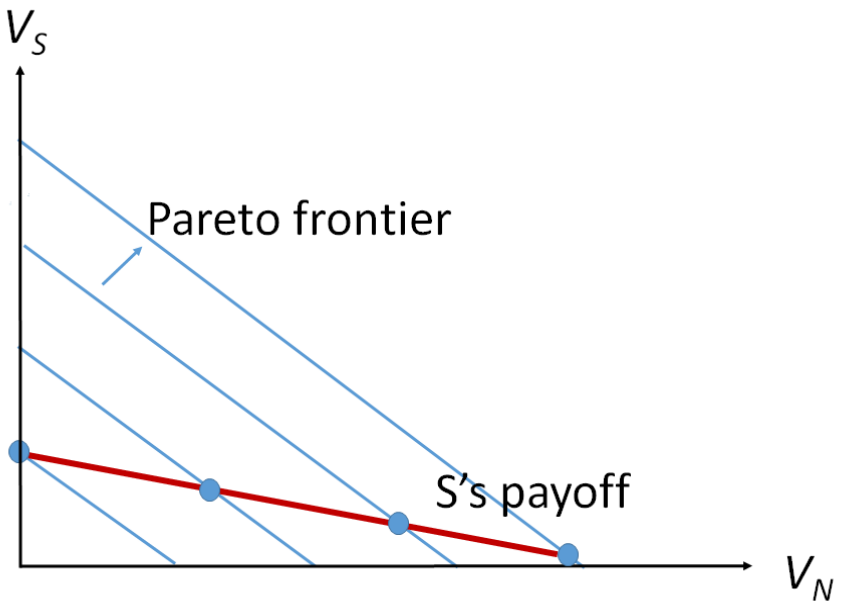
- Lemma 1: If S obtain less of these gains, S conserves.

CTA: Feasibility



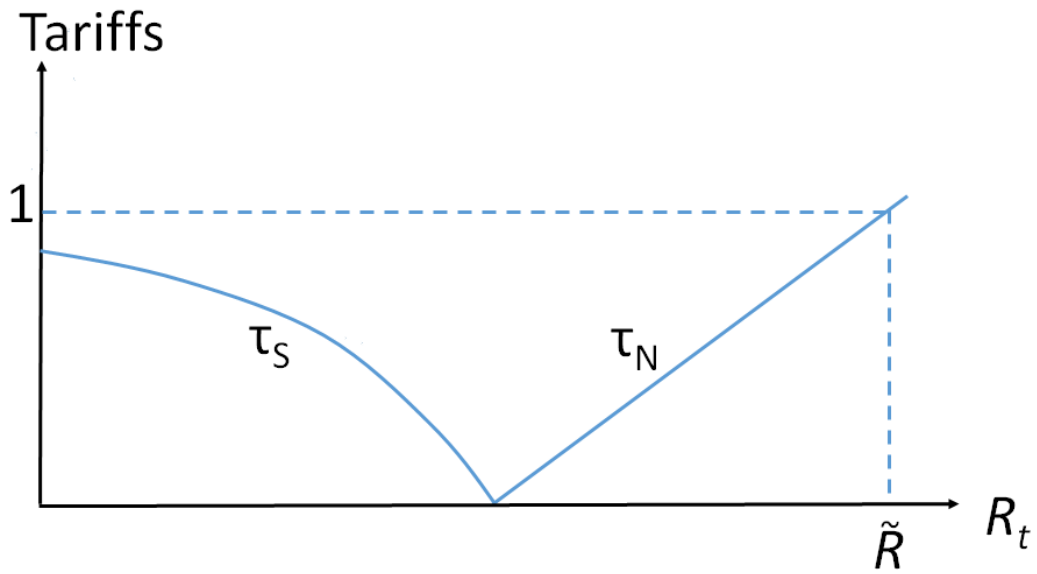
- Lemma 1: If S obtain less of these gains, S conserves.

CTA: Feasibility



- The CTA allows N and S to agree on such a path.

CTA: Feasibility



- To implement this, the terms of trade must be favorable to S if R_t is large.

CTA: Equilibrium

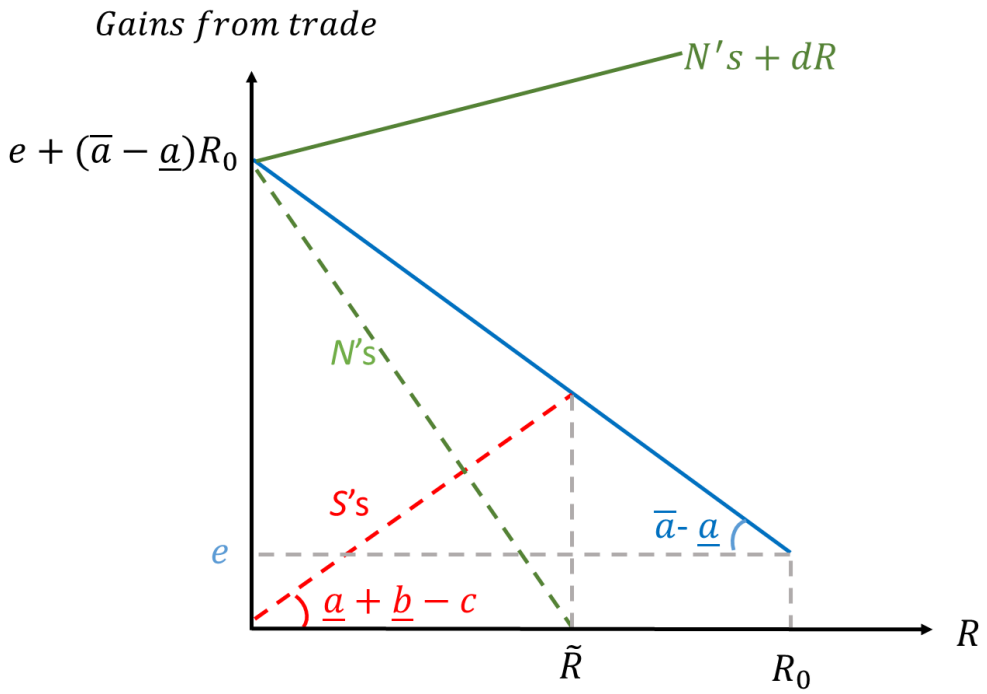
Proposition

Consider a subgame starting at time T without a CTA. In every MPE, N and S sign a CTA and implement the first-best outcome with $x_t = 0 \forall t \geq T$. The tariffs respect Lemma 1 and, when $R_t = R_T$:

$$\overline{\tau} = \left\{ \begin{array}{c} \alpha e - (1-\alpha)(\overline{a} - \underline{a}) R_0 + (1-\alpha)(\overline{a} - \underline{a}) R_T \\ \text{and } x^D = 0 \text{ if } \varphi < 0, \\ \alpha e - (1-\alpha)(\overline{a} - \underline{a}) R_0 + \frac{\underline{a}+\underline{b}-c}{\delta} R_T + (\overline{a} - \underline{a}) R_T \\ \text{and } x^D = \varphi R_T \text{ if } \varphi \in (0,1) \\ \alpha e - (1-\alpha)(\overline{a} - \underline{a}) R_0 + \left[(1-\alpha)(\overline{a} + \underline{b} - c) + \alpha d\right] R_T \\ \text{and } x^D = R_T \text{ if } \varphi > 1 \end{array} \right\}$$

$$\text{where } \varphi \equiv \frac{\delta\alpha(\overline{a} - \underline{a}) + \underline{a} + \underline{b} - c}{\delta\alpha(\overline{a} - \underline{a}) + \delta\alpha \frac{d+c-\overline{a}-\underline{b}}{1-\delta}}.$$

Limits of the CTA without export subsidies



- S must be better off when R_t is large (red dotted line).
- With limited gains from trade (blue line), at most $\widetilde{R}$ can be conserved.
- N's gains from trade must decrease in R_t.
- N is still better off when R_t is large.

CTA: Equilibrium Without Subsidies

Proposition

Suppose export/import subsidies are not available and that $\alpha = 0$.
(i) The tariffs are in line with Proposition 6 and $x_t = 0$ *for every* $t \geq T$ *if:*

$$R_T \leq \widetilde{R} \equiv \frac{e + (\overline{a} - \underline{a}) R_0}{\overline{a} + \underline{b} - c} \text{ or } \overline{a} + \underline{b} < c.$$

(ii) Otherwise, i.e., if $R_T > \widetilde{R} > 0$, *then, for every* $t \geq T$,

$$x_t = \left(R_t - \widetilde{R}\right) \gamma, \text{ where } \gamma \equiv 1 - \frac{\overline{b} - \underline{b}}{(1-\delta)(\overline{a} + \underline{b} - c) + \overline{b} - \underline{b}} \in (0, 1],$$

and, on the equilibrium path $\tau_S = 0$ *and* $\tau_N = 1$.

On Exhaustability and Irreversability

- The negative results on FTAs follow *because* the resource is exhaustible.
  - If R_t returned to R_0 after every period, or if the stock was not relevant, then N and S would always lose from trade if $\overline{a} + \overline{b} < c + d$, and S would not be able to exploit to obtain an FTA.
- The CTA can secure conservation *because* the resource is exhaustible.
  - If R_t returned to R_0 in every period, or if R_t were not relevant, then it would not be credible that $\overline{\tau}$ would decrease if S extracted.
  - If such a decrease could motivate S to conserve, then N would prefer to "restart the clock" after S had extracted.

Robustness

1. The CTA assumes that countries cannot commit to future agreements, but it implements the same payoffs as if they could.
2. The CTA is similar if the agreement is non-binding, i.e., if a country can unilaterally leave the agreement (with the intention of negotiating a new agreement).

Comparison to Commitment

Proposition

- *If N and S could commit to future policies as a function of the history, they would commit to trade and to cease trade if S depletes (too much).*
- *The CTAs described by Propositions 6 and 7 implement the same outcome, and secure the same payoffs, as N and S would have achieved if they could commit.*

- The CTA is not an arbitrary design from which N and S can make further improvements. The CTA implements the first best if export subsidies are available, and the second-best if they are not.

Robustness: Binding vs non-Binding Treaties

- Above, the treaty was binding unless both agreed to change it.
- If S can unilaterally leave the agreement, in order to negotiate a new agreement, we must impose a "renege constraint."
- The equilibrium CTA is qualitatively similar.
- If S walks away, depletes, and negotiate a new treaty, then N benefits less and $\overline{\tau}$ is smaller. This can be sufficient to discourage exploitation.

Proposition

(i) The equilibrium CTA is given by Proposition 6 unless $c \in (0, \alpha(\overline{a} - \underline{a}))$*, when, instead:*

$$\overline{\tau}(R_t) = \alpha e - (1-\alpha)(\overline{a} - \underline{a}) R_0 + (\overline{a} + \underline{b} - c) R_t.$$

In either case, the CTA implements the first best.
(ii) If export subsidies cannot be used, and $\alpha = 0$*, the equilibrium CTA is given by Proposition 7.*

Questions and Answers

1. Can trade cause deforestation? Or deforestation cause trade?

   Trade can cause deforestation, and deforestation can cause trade.

2. How can trade motivate conservation?

   Even in such a grim situation, a contingent trade agreement can motivate conservation.

3. Can we evaluate the proposal by France and the Netherlands?

The Proposal by France and the Netherlands

- Conservation *can* be motivated by "*staged implementation of tariff reduction linked to the effective implementation of TSD provisions.*"
- Making tariffs contingent on forest cover is renegotiation proof.
- In practice, verifiable measures of forest cover are available, thanks to satellite monitoring.
  - In India, the regional forest cover has, since 2015, been part of the central government's allocation of tax revenue to its 29 states (Busch and Mukherjee, 2018).
  - "*This represents the first large-scale ecological fiscal transfers for forest cover, and could serve as a model for other countries*" (Angelsen et al., 2018:51).
- Permitting export/import subsidies can increase the amount of conservation.

FTA vs. CTA

	FTA	**CTA**
(1)	$R^{FTA} \leq R^{AUT}$	$R^{CTA} \geq R^{AUT}$
(2)	More valuable if R small	More valuable if R large
(3)	Deplete to trade	Conserve for terms of trade
(4)	$x \uparrow$ if $e \uparrow$ or $R \downarrow$	$x \downarrow$ if $e \uparrow$ or $R \downarrow$
(5)	$\tau'_x(R) \leq 0 \leq \tau'_S(R)$	$\tau'_N(R) \geq 0 \geq \tau'_S(R)$
(6)	Inefficient	Efficient

Literature and further reading

The above model draws on the literature (surveyed by Maggi '14; Bagwell and Staiger '16): Tariff reductions are motivated by terms-of-trade effects (Bagwell and Staiger '04: '11; Ludema and Mayda '13; Grossman '16), transfers are possible (Aghion et al. '07; Maggi and Ossa '20). Here, we also consider export subsidies (Grossman and Helpman '95) and renegotiation (Ludema '01; Maggi and Staiger '15).

Trade can cause depletion (Markusen '75; Dasgupta et al. '78; Chichilnisky '94; Brander and Taylor '97; '98).

Solutions: Trade sanctions (Barrett '97), border tax adjustments (Hoel '96; Elliott et al. '10; Al Khourdajie and Finus '20), output-based rebates (Fischer and Fox '12), climate clubs (Nordhaus '15)...

Traditional threats to limit trade are not renegotiation proof when resources are exhaustible: After depletion, everyone gains from trade.

The above "solution" is inspired by renegotiation-proof cooperation in repeated games (Mailath and Samuelson '05).

A follow-up study on "Contingent trade agreements" consider a traditional trade model with nonlinear utility functions, noncooperative tariffs, and a more general