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Contact Address:
University of Innsbruck
Department of Public Finance
Universitaetsstrasse 15
A-6020 Innsbruck
Austria
Tel: + 43 512 507 7171
Fax: + 43 512 507 2970
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Does going green pay off? The effect of an international environmental agreement on tropical timber trade

Stefan Borsky*, Andrea Leiter* and Michael Pfaffermayr*

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Abstract

Trade-related measures aim to regulate side-effects in international environmental agreements and are expected to positively influence the level of participation in the agreements as well as their degree of stability. In this paper we examine one side-effect of the 1994 International Tropical Timber Agreement - its impact on tropical timber trade. We use a cross-sectional dataset on bilateral trade flows of tropical timber that additionally contains information on trading partners' economic and geographical characteristics. Our empirical specification is based on a gravity equation, which is estimated using Heckman's selection model to address the potentially systematic selection of trading partners. We find significantly positive impacts of the 1994 ITTA on member countries' level of tropical timber trade. Furthermore, poor exporter countries benefit more from this trade enhancing effect than their richer counterparts.

Keywords: International environmental agreements, side benefits, bilateral trade flows, product quality, sample selection.

JEL: F53, Q23, Q27, F18, L15

*University of Innsbruck, Faculty of Economics and Statistics, Universitaetsstrasse 15, A-6020 Innsbruck, Austria

1 Introduction

The accession of countries to an international environmental agreement not only affects the provision of an (global) environmental good, but also has an impact on various other issues. For example, in international trade relations it may shift the comparative advantage of the pollution-intensive industries in regulated countries to those in unregulated ones. Trade measures, which are regularly linked to international environmental agreements, aim to dampen these undesirable side-effects and are expected to positively influence the level of participation in and the stability of international environmental agreements. Despite the theoretic evidence of the importance of international environmental agreements containing trade related measures on the provision of global public goods, only few studies examine these issues econometrically.

Here is where our study starts. We analyze the effect of the 1994 International Tropical Timber Agreement (ITTA) on international trade of tropical timber (TT). First, we ask whether ITTA influences the firms' decision in the exporter country to serve a foreign market with TT well as the respective volume. This question is motivated by a recent article by Rose & Spiegel (2009) who demonstrate that non-economic exchange (e.g. political relations) between countries increases the likelihood of engaging in economic exchanges. Second, we decompose the effect of 1994 ITTA for different subsamples referring to their economic endowment to get an insight into the distribution of the agreement's effect across specific groups of countries. This is of particular interest as these distributional issues are frequently the reason of conflicts in international environmental negotiations.

To answer these research questions we rely on a theoretical model by Hallak (2010) who considers the relevance of quality parameters in determining bilateral trade flows. The econometric specification is based on a gravity equation which is estimated using the Heckman sample selection model to control for the potential systematic selection of countries into the group of tropical wood traders. We find that due to the linked trade measures countries participating in ITTA form an exclusive club, in which the trade intensity of TT rises significantly in comparison with countries outside the club. These impacts occur even though we control for the effect of preferential trade agreements between the countries as well as potential leakage effects that may influence the trade of TT of non-participating countries. With respect to the distribution of the agreement's impact on TT trade between importers and exporters that differ in their economic endowment we find that poor exporters benefit most by signing the ITTA. This result contradicts the frequently mentioned

concerns that developing countries are negatively affected by trade-related measures in international environmental agreements. Even more, this impact points to the possibility for convergence in trade volumes between rich and poor exporters, which would consequently increase the stability of the agreement.

To the best of our knowledge, this is the first study which empirically examines the trade effects of an international environmental agreement containing trade related measures. The quantification of such effects is important to compare the resulting benefits with the other benefits and costs that the agreement induces and to determine its net benefits and distribution among the participating as well as non-participating countries. Knowledge of the distribution of this impact across countries makes future negotiations on international environmental agreements more efficient.

The remainder of the paper is organized as follows. In section 2, we will introduce the international environmental agreement of our interest, the International Tropical Timber Agreement. Furthermore, we will give a brief literature overview on international environmental agreements and discuss the concept of linking trade-related measures in international environmental agreements in more detail. In section 3 we will describe our theoretical and empirical approach to analyze the trade effects of an international environmental agreement. In section 4 we will present our data and in section 5 we will discuss our results. The last section concludes.

2 Background and previous literature

2.1 The International Tropical Timber Agreement

In 1983, following a growing public debate on the problems of the substantial degradation and destruction of the world's forests, an international environmental agreement on management and trade of TT – the so called International Tropical Timber Agreement – was signed originally by 36 producer and 34 consumer countries and entered into force three years later. Under the agreement the International Tropical Timber Organization (ITTO) with its decision-making and recommendatory body, the International Tropical Timber Council, was established. The ITTA's primary objective is the protection of natural tropical forests from destruction, degradation and excision. Furthermore, the agreement aims at promoting TT trade by providing a platform that eases the communication between producers and consumers.

Until now the original agreement was renegotiated two times, in 1994 as well as in 2006. While the 1983 ITTA was originally designed as a commodity-based agreement with emphasis on strengthening the members' TT markets, the 1994 ITTA included

the 'ITTO Objective 2000' and the Bali Partnership Fund. These two measures have increased the importance of the primary objective - the sustainable use of the forest resource - substantially by implementing forest certification schemes, developing criteria and indicators for sustainable management, introducing community forestry schemes and making harvesting data of tropical wood more transparent. The 1994 ITTA is signed by 65 member countries whereof the producing member countries possess about 80 percent of the world's tropical forests. The succeeding 2006 ITTA, which is not into force yet, still aims at supporting sustainable tropical forest management and TT markets.

2.2 Previous literature

Today, environmental issues with transboundary impact, like ozone depletion, pollution of oceans and rivers, overexploitation of natural resources and deforestation of world's forests, are addressed in numerous international environmental agreements. Success or failure of such agreements often depend on both the participation and the compliance behavior of the involved countries. Many international environmental agreements share the following features, which restrain their success.

First, their main objective is the provision of a public good, which leads to collective action problems. Second, since states are sovereign in their decision to provide the public good or to free-ride on the others countries' behavior, international environmental agreements have to be self-enforcing (Barrett 1994).

Third, such agreements regularly bring countries together, which differ in their economic, institutional and ecologic endowment and therefore, share the benefits and costs of abatement asymmetrically. This is a major problem in the negotiations of international environmental agreements containing trade related measures. For this reason, developing countries often resist strongly to accede to these kind of international environmental agreements. Commonly, they argue that they may not be able to afford a raise in their environmental standards and that these trade measures will have a negative economic impact on them as a result of restrictions in market access through certification requirements, performance mandates, conformity assessments and labeling standards (Brack & Gray 2003, Qiu & Zhihao 2009).

Fourth, international environmental agreements regularly interact with other markets in many different ways. Suppose, for example that a country' s production is more costly due to its participation in an international environmental agreement. Then, the comparative advantage of the pollution-intensive industries will shift to non-participating countries and the world price will change. In particular, the non-

participating countries will increase their output of the dirty good leading to a situation in which the provision of the global public good is less than the initial level of provision undertaken by the participating countries (Copeland & Taylor 2005). This phenomenon is known as leakage effect. Furthermore, leakage increases the incentive to free-ride if the free-riders' benefits from consumption of the public good that complying countries provide are sufficiently large. Providing a credible set of specific sanctions for non-complying and non-participating countries can reduce or even eliminate leakage effects (Barrett 1997). Trade related measures enable the member countries to observe the compliant behavior of their trading partners. This increased market transparency creates peer pressure to comply with the agreements obligations as non-compliant countries may face a worsening of their international relationships.

To overcome these problems, the literature on international environmental agreements suggests rearranging the incentive structure so that instable coalition partners join the agreement and comply with the agreement's obligations (Barrett & Stavins 2003). This can be done for instance by linking different policy issues.[1] Alternative measures influencing the incentive structure of international environmental agreement discussed in the literature are a minimum participation clause (Carraro, Marchiori & Oreffice 2009, Barrett 1998), in-kind and cash transfers (Carraro & Siniscalco 1993, Hoel & Schneider 1997, Barrett 2001), uniform emission reduction quotas (Endres & Finus 2002, Finus 2003) and sanctions (Barrett & Stavins 2003).[2]

Since the early 1990s, the literature about the effects of different policy measures on the formation and stability of international environmental agreements has grown continuously. While this literature mainly uses game theoretic approaches, only a few studies investigate these issues systematically in an econometric framework.[3] The majority of the empirical contributions to the literature on international environmental agreements deals with the participation decision of countries and the

[1] See for example Barrett (1997), Barrett (2006), Carraro & Siniscalco (1997), Hoel & de Zeeuw (2010).

[2] For an overview on the existing literature and an excellent discussion see for instance Wagner (2001) or Finus (2008).

[3] Another strand of literature examines the success of international environmental agreements in reaching the specified environmental target. Murdoch & Sandler (1997) and Murdoch, Sandler & Sargent (1997) evaluated the effects of the Montreal Protocol on CFC emissions and the Oslo Protocol sulphur emissions respectively. Their results suggest that the cooperative gains are not significant higher than the non-cooperative gains. Finus & Tjøtta (2003) examining the 1994 Oslo Protocol, Bratberg, Tjøtta & Torgeir (2005) evaluating the impact of the 1988 Sofia Protocol and Aakvika & Tjøtta (2011) analyzing the 1985 Helsinki Protocol and the 1994 Oslo Protocol could determine cooperative gains compared to the non-cooperative outcome.

factors influencing this decision (Murdoch, Sandler & Vijverberg 2003, Beron, Murdoch & Vijverberg 2003, Fredriksson, Neumayer & Ujhelyi 2007).

In a recent article, Rose & Spiegel (2009) theoretically demonstrate that non-economic exchange between countries increases the likelihood of engaging in economic exchanges. This arises from the fact that non-economic engagement, first, can signal a higher level of trustworthiness and, second, provides the possibility of punishing the partner in one domain for non-cooperation in the other domain. In a further step, they find empirical support that countries with a greater participation in international environmental agreements also have higher trade in financial assets. They conclude that non-cooperative behavior is costly for countries due to the lost of such indirect benefits. In contrast to Rose & Spiegel (2009), in this work the link between the agreement's impact and the commodity exchange is much tighter as we focus on the specific goods the agreement explicitly refers to (i.e. trade in TT).

2.3 Trade-Related Measures in International Environmental Agreements

Trade-related measures are only one part of a range of instruments designed to increase the formation and stability of multilateral agreements. Today they are integrated in a great number of international environmental agreements on a wide range of topics. Examples are the Montreal Protocol on Substances that Deplete the Ozone Layer, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, the Convention on International Trade of Endangered Species and the agreement of our interest, the 1994 ITTA, promoting the sustainable management of tropical forests, the development of tropical forest industries through international cooperation and the international trade in TT.[4] Trade-related measures help to improve the participation in and compliance with international environmental agreements, if markets are imperfect and distorted by asymmetries, if policy failures have to be corrected for or if strong incentives to free-riding and leakage exists. Furthermore, they provide a possibility of monitoring and controlling trade in products, in which otherwise unregulated trade would contribute to environmental damage, like in the Convention on International Trade of Endangered Species or the ITTA.[5]

[4] For an detailed overview and discussion of international environmental agreements containing trade-related measures see WTO, *Matrix on Trade Measures Pursuant to Selected MEAs*, WT/CTE/W/160/Rev.1(2001).

[5] For a general analysis and discussion of trade-related measures in international environmental agreements see Brack & Gray (2003) or Hoffmann (2004).

Trade related measures vary widely and include on the one hand specific reporting, labeling or other identifications requirements, like movement documents and on the other hand more invasive forms, like general and targeted import/export bans and market transformation measures, like tariffs, subsidies or other forms of fiscal measures (Brack & Gray 2003). Invasive forms provide an instrument of first, punishing non-cooperative behavior of participating countries, and second, reducing the comparative advantage of non-participating countries and in this way easing the problem of leakage. To influence behavior, these threatened punishments must be both credible and sufficiently severe (Barrett & Stavins 2003). But these requirements are difficult to fulfill, because every punishment harms cooperating as well as non-cooperating countries. Furthermore, due to the fact that countries interact on various issues and through numerous channels applications of trade restrictions can be limited, for example in cases where trade restrictions violate the non-discrimination provision of the GATT/WTO agreement (Barrett 1997). Therefore, trade-related measures in international environmental agreements are usually part of a package of measures that include non-invasive measures, like reporting, labeling and information requirements, non-trade measures, like quotas, and supportive measures which can be financial and technical support, training and R&D linkages (Hoffmann 2004). The 1994 ITTA consists of non-invasive measures, like increasing market transparency, providing trade and price data, reducing market distorting illegal logging practices or providing a platform for producers and consumers of tropical wood. Additionally, supportive measures have been included by introducing the Bali Partnership Fund, which allocates financial assistance to ITTA-producer countries to implement a more sustainable management of TT.

3 Theoretical model and empirical specification

3.1 Theoretical framework

We base our theoretical model for TT on the arguments given in Anderson & van Wincoop (2003), Hallak (2010) and Anderson & Yotov (2010). Accordingly, we assume that the demand for country i's tropical wood exports to country j, x_{ij}, are based on a monopolistic competition model with CES-preferences. For each of the n_i tropical wood extracting firms (varieties) in country i the demand function in

country j is given by

$$x_{ij} = \frac{\left(\frac{p_i \tau_{ij}}{\theta_i^{\gamma_j}}\right)^{-\sigma}}{\sum_{h=1}^{J} n_h \left(\frac{p_h \tau_{hj}}{\theta_h^{\gamma_j}}\right)^{1-\sigma}} \phi Y_j. \tag{1}$$

$\sigma > 1$ and denotes the elasticity of substitution, which is constant and uniform across countries. τ_{ij} represents iceberg-type transportation costs. Following Hallak (2010), θ_i is a (environmental) quality indicator for production, γ_j stands for the intensity of the consumers' preference for (environmental) quality. ϕY_j defines the expenditures on wood products which are a fraction ϕ of GDP Y_j. Mark-up pricing of firms in country i leads to mills prices

$$p_i = \tfrac{\sigma}{\sigma-1} c_i, \tag{2}$$

where c_i stands for marginal costs of wood production, which are assumed to be the same for all firms in a country.

The crucial determinant in this analysis is the role of product (environmental) quality, pictured by $\theta_i^{\gamma_j}$, in trading TT. To keep the model simple we assume that the supply of higher environmental quality is associated with higher fixed costs but does not effect the variable costs. As Hallak (2010), we suppose that demand and supply for environmental quality is positively related to both, the log of real income per-capita of the suppliers, y_i, and the consumers, y_j. Additionally, we assume that the supply of and demand for environmental qualitative TT products is higher for countries that signed the 1994 ITTA. Specifically, θ_i and γ_j are parameterized as

$$\begin{aligned} \theta_i &= e^{kD_i} e^{\alpha y_i} \\ \gamma_j &= \delta D_j + \beta y_j. \end{aligned}$$

so that after taking logs one obtains

$$\begin{aligned} \gamma_j \ln \theta_i &= (\delta D_j + \beta y_j)(D_i k + \alpha y_i) \\ &= \delta k D_j D_i + \beta D_i k y_j + \delta \alpha D_j y_i + \beta \alpha y_j y_i \end{aligned} \tag{3}$$

We define $D_i = 0$ whenever an exporter is not an ITTA-member, i.e. only supplies a base quality. $D_i = 1$ indicates that the exporter provides a higher environmental quality due to its ITTA status. Similarly, $D_j = 1$ ($D_j = 0$) if the importing country is (not) part of the 1994 ITTA. This formulation implies that the trading partners'

ITTA status as well as their GDP/capita influences quality demand and supply. We argue that rich countries tend to consume products with a high environmental quality in the sense that their willingness to pay for quality level θ_i, captured by γ_j, is higher the richer the people in the importing country are. In addition, signing the 1994 ITTA ($D_j = 1$) as an importer country reveals its preference for higher environmental quality. Also, rich countries are more able to supply high environmental quality and if they sign the 1994 ITTA as a supplier ($D_i = 1$) they will provide higher environmental quality as compared to the base level. The base effect, i.e. $D_i = 0$ and $D_j = 0$, is solely determined by the exporters' and importers' GDP/capita, i.e., y_i and y_j. As Hallak (2010) shows, this term can be used to test the Linder hypothesis which suggests that countries with similar GDP/capita trade more intensively with each other. Depending on the trading partners' status of their ITTA-membership and their GDP/capita, we observe four different combinations of the environmental quality effects of ITTA:

$$\begin{aligned}
\ln(\theta_i^{\gamma_j}) &= \beta\alpha y_j y_i && \text{if } D_i = 0 \text{ and } D_j = 0 \\
\ln(\theta_i^{\gamma_j}) &= \beta\alpha y_j y_i + \delta\alpha D_j y_i && \text{if } D_i = 0 \text{ and } D_j = 1 \\
\ln(\theta_i^{\gamma_j}) &= \beta\alpha y_j y_i + \beta D_i k y_j && \text{if } D_i = 1 \text{ and } D_j = 0 \\
\ln(\theta_i^{\gamma_j}) &= \beta\alpha y_j y_i + \delta\alpha D_j y_i + \beta D_i k y_j + \delta k D_j D_i && \text{if } D_i = 1 \text{ and } D_j = 1
\end{aligned} \tag{4}$$

Considering that countries may systematically select into the group of TT traders, we end up with two crucial equations upon which the econometric specification can be based.[6] The first equation refers to the nominal value of TT exports of country i to country j, X_{ij}:

$$\ln X_{ij} = (1-\sigma)\ln\tau_{ij} + (\sigma-1)\gamma_j \ln\theta_i + \ln(\lambda_j P_j^{\sigma-1}) + \ln\left(\vartheta_i \Pi_i^{\sigma-1}\right) + \ln(Y\phi) \quad \text{if } V_{ij} = 1 \text{ and } 0 \text{ otherwise} \tag{5}$$

Equation (5) indicates that the value of bilateral TT trade is increasing in product quality, in demand for quality, in income and in the trade resistance terms which cover the average prices on the demand and supply side. TT trade is decreasing the higher the transportation costs are. However, trade in TT can be only observed, if exporter i serves the import market j, i.e. if $V_{ij} = 1$.

The second equations models V_{ij}. Following the literature, we assume free entry of suppliers into the import markets at fixed costs (f_{ij}) which drives profits down to

[6] A detailed discussion of the theoretical motivation is given in the Appendix.

zero. Based on this zero profit condition and under the assumption that exporter profits are separable across destination countries one may define a latent variable (V_{ij}^*) that captures the propensity of exporter country i to serve import market j. In our model we specify the latent variable as

$$V_{ij}^* = (1-\sigma)\ln\tau_{ij} + \sigma(\gamma_j - \gamma_i)\ln\theta_i + \ln(P_j^{\sigma-1}Y_j) - \ln\left(P_i^{\sigma-1}Y_i\right) + \ln\left(\frac{f_{ii}}{f_{ij}}\right) \quad (6)$$

and define the indicator variable V_{ij} taking the value 1 if exports from country i to j are observed and 0 otherwise. This specification is obtained by normalizing the zero profit condition of firms exporting from country i to j by the operating profits earned in the domestic market (see Appendix). It implies that exports from i to j are more likely observed the lower the trade barriers τ_{ij} and the fixed trade costs f_{ij} are. Note, the importer trade resistance terms P_j (P_i) affect the propensity to export since a higher average price level in a market increases the operating profits earned there.

Concluding, the participation in ITTA does not only influence the magnitude of the trade flows (internal margin) but also the decision of an exporter to serve a foreign market at all (external margin).

3.2 Econometric specification

The structural gravity equation discussed shortly above and derived in the Appendix motivates to estimate a Heckman-sample selection model (Heckman 1976) with exporter and importer dummies. These dummies capture all determinants that are either importer or exporter specific. In particular, in the trade flow equation the dummies cover the trade resistance terms $\ln(\lambda_j P_j^{\sigma-1})$ and $\ln\left(\vartheta_i \Pi_i^{\sigma-1}\right)$, while the exporter and importer dummies of the selection equation capture the terms $\gamma_i \ln\theta_i$, $\ln(P_j^{\sigma-1}Y_j)$ and $\ln\left(P_i^{\sigma-1}Y_i\right)$.

The econometric model estimated below pools over four product classes indexed by z. We substitute $\gamma_j \ln\theta_i$ in equation (5) by equation (3) and add a stochastic disturbance term. Then, country i's nominal exports to country j of products z, X_{ijz}, can be described as follows

$$\begin{aligned}\ln X_{ijz} = {} & a_0 + a_1(\ln y_j - \ln y_i)^2 + a_2 D_j \ln y_i + a_3 D_i \ln y_j + a_4 D_j D_i \\ & + a_5 \tau_{ij} + c_i + m_j + p_z + \epsilon_{ijz}\end{aligned} \quad (7)$$

y_j (y_i) represents the importer's (exporter's) GDP/capita. D_j (D_i) describes the country's ITTA membership and equals one when the importer (exporter) acceded

to the 1994 ITTA, $D_j D_i$ is one if both trading partners signed the ITTA. $(\ln y_j - \ln y_i)$ stands for the Linder term and measures the distance in the countries' GDP/capita.[7] τ comprises the bilateral trade barrier variables. In particular, it includes regional trade agreements (RTA) in force, the log of geographical distance (measured in km) between the countries' main cities, and dummies for having a common border, colonial relationship, common colonizer and common language. Finally, c_i, m_j and p_z capture exporter, importer and product fixed effects and ϵ represents the error term.

We expect a positive sign on a_2, a_3 and a_4 indicating that high preferences for environmental quality together with the provision of environmentally qualitative goods increase the nominal value of TT trade. According to the Linder Hypothesis, a_1 should be negative as countries that are dissimilar in their GDP/capita are expected to trade less intensively with each other.

As highlighted above, one has to control for the systematic selection of countries into the group of TT traders. The parameterization of participation in TT trade is based on equation (6). Since fixed trade costs remain unobserved, we use the same explanatory variables as in the trade flows equation as theory does not provide observable bilateral indicators that would define exclusion restrictions.[8]

$$\begin{aligned} \ln V^*_{ijz} = {} & b_0 + b_1(\ln y_j - \ln y_i)^2 + b_2 D_j \ln y_i + b_3 D_i \ln y_j + b_4 D_j D_i \\ & + b_5 \tau_{ij} + c_i + m_j + p_z + \nu_{ijz} \end{aligned} \tag{8}$$

Finally, we want to emphasize that we do not consider the endogeneity of the ITTA dummy variables as an important issue in our context. The reason is that a country's decision to signing up the ITTA either as exporter or importer is unilateral. In other words, the countries' ITTA status does not refer to a specific bilateral relationship but pictures a unilateral decision. Therefore a countrie's ITTA status can be seen as an exogenous treatment in bilateral setting where endogeneity is related to disturbances varying at the bilateral level. To justify this statement, we tested for the endogeneity of the ITTA status among the TT traders (i.e. ignoring zero trades) and find support for the exogenous treatment assumption.

[7] Note, that the squared log difference in the countries GDP/capita can be derived from $\ln y_j \ln y_i$ considering that $\ln y_j \ln y_i = 0.5 \ln y_j^2 + 0.5 \ln y_i^2 - 0.5(\ln y_j - \ln y_i)^2$. y_j^2 and y_i^2 are captured in the importer and exporter fixed effects.

[8] Cameron & Trivedi (2005), Chapter 16.5.5., show that the model is identified without exclusion restrictions but the identification may be weak if the fit of the probit model is poor. In our case, these identification problems seem not to be an issue.

4 The data

4.1 Data description and modification

The data stems from a number of sources. Information on bilateral TT imports are taken from the UN's commodity trade statistic database, which reports trade data up to a 6 digit classification of products. In particular, we examine nominal trade flows of TT[9]. We refer to the Harmonized Commodity Description and Coding System 1996 (HS1996) which classifies TT into 10 different codes (for a detail definition, see Table A2 in the Appendix) and covers a period of 13 years (1996 to 2008). Geographical information (distance between the trading partners, common language, contiguity, colonial linkages) is taken form the CEPII data base. Data on the trading partners' GDP/capita stem from the World Development Indicators 2009 compiled by the World Bank. Regional trade agreements in force are taken from Baier, Bergstrand, Egger & McLaughlin (2008) and from the WTO's Regional Trade Agreements Information System[10]. Our crucial independent variable, the status of a country's ITTA membership, is defined through Annex A and Annex B of the 1994 International Tropical Timber Agreement (ITTA 1994).

Unfortunately, for some trading partners only a few observations per product class and year are available. We therefore average our sample over time and 4-digit classes (instead of using the 6-digit classification). As the set of countries that trade TT may systematically differ from the countries that do not trade, we start with a sample of all exporter and importer countries that reported at least one trade flow. We drop exporters that are not tropical countries as they – by definition – cannot produce tropical wood (but rather represent intermediary trade partners). We are left with a sample of 47,628 observations whereof about 10 % (i.e., 4,753 observations) include information on TT trade, i.e. imports in TT > 0.

4.2 Descriptive statistics

As shown in the Table 1, the average value of TT imported amounts to 742,500 US$. The average GDP/capita (measured in constant year 2000 US$) of the importers is more than twice as large as the average GDP/capita of the exporting country. The average distance between the two trading partner is about 8,700 km and only 2 % of the trading partners share a common border. In 20 % of the observations the

[9] According to ITTA, TT is defined as non-coniferous tropical wood for industrial uses, which grows or is produced in the countries situated between the Tropic of Cancer and the Tropic of Capricorn. This definition involve logs, veneer sheets, sawnwood and plywood (ITTA 1994).

[10] http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx

trading partner have their language in common, in about 14 % they have (had) a commom colonizer and in about 1% they have (had) colonial links. Regional trade agreements are in force between 18 % of the trading partners and in about 40 % of all observations one of the trading partners have signed the 1994 ITTA. Finally, in 15 % of the observations both, exporter as well as importer, are ITTA members.

Table 1: Descriptive Statistics

Variable	Obs.	Mean	Std.Dev.	Min.	Max.
Imports (in 1,000 US$)	4753	742.526	10150.280	0.004	594300
GDP/capita (importer)	47628	7221.197	9859.441	110.310	47608
GDP/capita (exporter)	47628	3250.131	4886.590	110.281	26698
Distance (in km)	47628	8694.206	4451.390	105.181	19904
Contiguity	47628	0.016	0.127	0	1
Com. language	47628	0.203	0.402	0	1
Colonial link	47628	0.008	0.087	0	1
Com. Colonizer	47628	0.137	0.344	0	1
Regional trade agreements	47628	0.184	0.387	0	1
ITTA (importer)	47628	0.385	0.487	0	1
ITTA (exporter)	47628	0.395	0.489	0	1
$ITTA_{imp}$*$ITTA_{exp}$	47628	0.150	0.358	0	1

148 importing and 81 exporting countries are involved in trading TT. Table 2 lists the ten largest importers and exporters with respect to the aggregated value of TT imported. All of these countries, except for Belgium, have signed the 1994 ITTA. As Table 2 highlights, Japan is by far the largest importer of TT and spends more than one billion US$ on TT. The United States and China rank second and third, respectively. India and Malaysia are the two most important supplier followed by Gabon whose exports are only about one third in value.

Table 3 presents the trade flows in TT in percent of the total import value for each continent pair. About 50 % of the total TT trade occurs within Asia. Trade flows from Africa to Europe (Asia to Europe) rank second (third) but are considerably lower, namely 15 % (9 %). The fourth most important destination for TT originated in Asia are the United states accounting for a proportion of 8 %. The remaining exporter-importer combinations are with respect to the import value as well as quantity imported of minor relevance. Overall, Asia accounts for 56 %, Europe for 26 % and North America for 13 % of the total import value of TT. The largest exporters (ranked by the import value of TT) are Asia, Africa and South America whose shares amount to 67 %, 24 % and 7 %, respectively.

Table 4 compares the trade flows across countries that signed or did not signed the 1994 ITTA. Among the four subgroups, the group where both trading partners

Table 2: Largest importers and exporters of TT (ranked by aggregated value imported[a])

Importers		*Exporters*	
of tropical timber trade (codes 4403, 4407, 4408, 4412)			
Japan	1063	India	1122
United States	362	Malaysia	922
China	274	Gabon	310
Republic of Korea	235	Cameroon	261
Italy	145	China	187
France	143	Brazil	135
India	113	Cote d'Ivoire	135
Germany	104	Ghana	83
Netherlands	94	Ecuador	31
Belgium	92	Peru	30

Notes: [a] Sum of TT imports/exports (in million US$).

Table 3: Trade flows in TT in % of import value

Exporter	*Importer*						
	(1)	(2)	(3)	(4)	(5)	(6)	Total
TT, overall import value: 3,529 mill. USD							
(1) Africa	1.98	6.61	0.05	14.54	1.06	0.05	24.29
(2) Asia	1.47	47.54	0.71	8.78	8.21	0.12	66.84
(3) Australia	0.01	0.16	0.05	0.05	0.09	–	0.35
(4) Europe	–	–	–	–	–	–	–
(5) North America	0.01	0.53	0.00	0.18	0.46	0.01	1.18
(6) South America	0.06	1.47	0.05	2.10	3.00	0.65	7.33
Total	3.530	56.31	0.86	25.65	12.82	0.83	100.00

Notes: Figures are based on the aggregate bilateral trade flows for the product classes 4403, 4407, 4408 and 4412. '–' indicates that no bilateral trade flows occurred between these regions; '0.00' means that bilateral trade is of minor value (smaller than a one-hundredth of a percent).

assigned the 1994 ITTA, accounts for 84 % of total trade flows. Second rank those countries where the exporter but not the importer is an ITTA member but the respective trade share is considerably lower (13 %) than for the former group.

Clearly, this huge difference may result from various factors that are unrelated to the countries' ITTA status. The following section aims at analyzing the trade flows in more detail and to focus on the role of ITTA assignments for the nominal value of TT trade.

Table 4: Trade flows in TT in % of import value and quantity

Exporter	*Importer*		
	(1)	(2)	Total
TT, overall import value: 3,529 mill. USD			
(1) no ITTA	1.03	2.13	3.15
(2) ITTA	12.87	83.98	96.85
Total	13.90	86.10	100.00

Notes: Figures are based on the aggregate bilateral trade flows for the product classes 4403, 4407, 4408 and 4412.

5 The estimation results

Our results are based on the econometric specifications derived in Section 3.2. As argued, we control for potential selection among trading partners by implementing Heckman's two-step estimator. The respective output is given in Table 5 and shows the selection and outcome equation.

Table 5: Trade flows in TT – estimation results

	Heckman's selection model	
Independent variable	selection	outcome
$D_i D_j$	0.105^{*}	0.518^{***}
$D_i * \ln y_j$	0.112^{***}	0.159^{***}
$D_j * \ln y_i$	-0.011	-0.094^{**}
$(\ln y_i - \ln y_j)^2$	0.008^{**}	-0.020^{**}
RTA	0.134^{***}	-0.045
$\ln distance$	-0.769^{***}	-1.157^{***}
contiguity	0.546^{***}	0.277^{*}
comlanguage	0.296^{***}	0.305^{***}
comcolonizer	0.276^{***}	0.339^{**}
colony	0.295^{***}	0.515^{***}
Mills ratio	1.552^{***}	
Observations	47628	
F-tests		
Product class effects	1403.36^{***}	
Exporter and importer effects	6844.38^{***}	

Notes: Constant and fixed effects not reported. *, ** and *** indicate 10%, 5% and 1% levels of significance.

Table 5 highlights that distance significantly determines the probability of taking part in TT trading. In particular, the probability decreases with increasing geographical distance (measured in km^2) and is higher for countries that share a common border, have a common language or have (had) colonial relationships. We also find strong evidence that the existence of a regional trade agreement makes it more likely that countries trade with each other. With respect to the 1994 ITTA and the countries' GDP/capita (i.e., our proxies for environmental quality) we find that the probability of trading is higher if both trading partners acceded to the 1994 ITTA. While the probability further increases in GDP/capita of the importer, given that the exporter signed the 1994 ITTA, the exporter's GDP/capita does not make positive trade flows more likely. Finally, the quadratic log difference in the countries' GDP/capita indicates that the probability of trading is higher for trading partners that diverge with respect to their GDP/capita.

Which effect do we find for the nominal value of trade flows? First of all, the significant mills ratio shown in the Heckman specification provides evidence that systematic selection is an issue and has to be controlled for to achieve reliable estimates. With respect to the influence of the distance parameters we find similar effects as in the selection regression with the exception that RTAs in force increase the probability of trading but do not affect the level of TT trade.

With respect to the environmental quality indicators we find that the base effect, the coefficient on the Linder term (i.e., quadratic log difference in the trading partner's GDP/capita), supports the Linder hypothesis which supposes that countries with dissimilar production and consumption patterns trade less intensely with each other. The positive and highly significant coefficient on $D_i D_j$ indicates higher trade flows if both trading partners approved the 1994 ITTA. Given that the exporter signed the 1994 ITTA, TT shipments rise with increasing GDP/capita of the importer. While the exporter's GDP/capita does not influence the probability of trading, its interaction with the importer's ITTA status is significantly negative in the outcome equation indicating lower trade flows with increasing GDP/capita of the exporter.

The effect of ITTA, captured by $D_i D_j$, results from two sources. First, by agreeing on trade requirements ITTA signatories can reduce their transaction costs. Second, $D_i D_j$ also indicates that the importer's preference for environmental quality is matched by the exporter's qualitative production. As we see, these factors increase the probability of TT trading as well as its volume. The interactions with the 1994 ITTA assignment dummies and the trading partners GDP/capita also reveal interesting patterns. The coefficient on the first interaction, the exporter's ITTA

membership with the importer's GDP/capita, imply that once the exporter exhibits a qualitatively higher production (i.e., signs the 1994 ITTA), the probability as well as the magnitude of TT trade is increasing in GDP/capita of the importer. The second interaction, importer's ITTA status with the exporter's GDP/capita, reveals that - given the importer acceded to the 1994 ITTA - poor countries are able to export more than rich exporting countries. This significant effect is the only one which does not meet our expectations: Given, that rich exporters have a comparative advantage in producing high quality goods the importer demands (ITTA member), we would have expected that the trade flows increase with increasing GDP/capita of the exporter (see Hallak (2010)). One explanation for that finding could be that richer exporters on average provide better quality and higher quality induces higher marginal costs. Overall, this may lead to a negative impact of quality increases on the quantity demanded if the impact of higher quality is outweighed by higher marginal costs (see Crozet, Head & Mayer (2011)).

Overall, these effects show that ITTA significantly determines the probability of positive TT trade flows as well as their value. But how would have the trade flows looked liked in a world with no 1994 ITTA in force? We answer this question by creating a counterfactual that represents a world where neither the exporter nor the importer are ITTA signatories, i.e., $D_i = D_j = 0$ and, hence, $D_j D_i = 0$. Using the Heckman estimates shown in Table 5, we predict the conditional means in TT imports for the country's current ITTA status and compare these values with the respective output in the counterfactual world. Accordingly, we determine the difference in the propensity of trading by comparing the actual with the constructed situation.

We interpret the estimated effect of ITTA membership analogously to Feenstra (2002) who analyzed the impact of common borders on the size of bilateral trade flows. In particular he proofed that the estimated coefficient of the border dummy can be used to calculate border effects on intranational (between the regions in the US and between the regions in Canada) trade in relation to international trade (between US regions and Canadian regions). In our context, the change in average trade flows due to the countries' ITTA membership is measured as relation between the observed versus the counterfactual outcome (i.e. no ITTA membership) of the ITTA members relative to the corresponding change in the average trade flows of those country pairs, where at least one partner is not an ITTA member. As shown by Feenstra (2002), this measure pictures the *average* effect of 1994 ITTA membership on TT trade relative to trade flows of non-members. In this way it is possible to

account for the fact that agreement membership also affects trade-flows by non-member countries, i.e. possible leakage effects of the agreement.

As we are interested in examining potential differences in the trade effects between rich and poor traders, we distinguish between four groups of participants: poor exporter and importer; poor exporter and rich importer; rich exporter and poor importer and rich exporter and importer. We define countries as poor (rich) if their GDP/capita lies below (above) the 25th (75th) percentile. Table 6 shows the mean effects of the 1994 ITTA membership for all exporters and importers if they are both ITTA members compared to a situation where only one of them or non of them signed the ITTA.

Table 6: Trade effects of ITTA membership

Exporter	*Change in trade flows*[a]			*Change in propensity*[a]		
	Importer			*Importer*		
	Poor	Rich	Total	Poor	Rich	Total
Poor	32.58	81.13	75.48	5.47	26.42	20.83
Rich	8.72	47.46	44.46	3.46	25.52	18.99
Total	17.77	56.91	53.44	3.99	25.78	19.52

Notes: Poor (rich) country, if country's GDP/capita is below (above) the 25th (75th) percentile. [a] Mean difference in trade flows (in %) and in exporter status (in percentage points) between a situation where both trading partners are ITTA members compared to a world where at least one trading partner is not an ITTA member (i.e., $D_i D_j = 0$).

The impact of the 1994 ITTA on the level of trade is largest if poor exporting and rich importing countries trade with each other. In this case, TT trade is 81 % higher than if the countries were not signatories. The group of rich exporters and rich importers (poor exporters and importers) that both signed the ITTA rank second (third) with an increase of 47 % (33 %) in trade flows compared to the counterfactual of no ITTA membership. Overall, poor exporters face an increase of 75 % in TT shipments due to their ITTA-membership while rich importers (exporters) can enhance their imports by 57 % (44 %). Poor importers experience the modest rise of 18 % in TT shipments.

Our theoretical and empirical evidence suggest that the 1994 ITTA also determines the propensity of trading. The respective figures in Table 6 reveal only minor variation between poor and rich exporters while the difference between poor and rich importers is considerable. In particular, the increase in the probability of trading with rich (poor) importers amounts to about 26 (3 to 5) % points for the poor as well

as the rich exporters.[11] From this follows that the overall increase in the propensity of trading due to the ITTA membership is highest for rich importers (26 % points) while rich and poor exporters face a similar rise (about 19 to 21 % points). As with the trade flows, the impact of ITTA is smallest for poor importers (4 % points).

6 Conclusions

This paper examines the impact of the International Tropical Timber Agreement on the propensity of trading tropical timber and the level of tropical timber shipments. We use a monopolistic competition setting that allows for implementing environmental quality indicators to derive relevant factors that determine the probability and level of tropical timber trade. The theoretical model suggests that the environmental quality in production and the consumers' preference for environmental quality determine the probability of trading as well as the level of trade. The model also motivates the use of Heckman's two-step estimator for the empirical analysis in order to control for systematic selection of traders.

We use data on bilateral trade flows in tropical timber which serves as the dependent variable in this analysis. Environmental quality in production and demand for environmental quality is pictured by the trading partners' GDP/capita and their ITTA membership. Information on bilateral distances as well as membership in preferential trade agreements are included as further control variables.

The estimation results reveal that countries, participating in ITTA, are going to form an exclusive club, in which the average trade intensity of tropical timber significantly rises in comparison with countries outside the club. This impact is strong enough to emerge even though we control for the effect of preferential trade agreements between the countries as well as potential leakage effects influencing the trade in tropical timber. Furthermore, we picture the distribution of the ITTA's trade impact between importing and exporting countries that differ in their GDP/capita and find that poor exporters benefit most by signing the agreement. These results are in contrast with the common argument that trade measures linked to international environmental agreements adversely affect developing countries. To conclude, trade related measures in international environmental agreements have the potential to decrease undesired side effects, such as asymmetries in trade benefits, and may therefore enhance the agreement's stability.

[11] Strictly speaking, this effect is just a lower bound as effects on the importer price resistance terms remain unidentified in a probit model with fixed exporter and importer dummies.

References

Aakvika, A. & Tjøtta (2011), 'Do collective actions clear common air? the effect of international environmental protocols on sulphur emissions', *European Journal of Political Economy* **27**(2), 343–351.

Anderson, J. E. & van Wincoop, E. (2003), 'Gravity with Gravitas: A Solution to the Border Puzzle', *American Economic Review* **93**, 170–192.

Anderson, J. E. & Yotov, Y. V. (2010), 'The Changing Incidence of Geography', *American Economic Review* **100**, 2157–2186.

Baier, S. L., Bergstrand, J. H., Egger, P. & McLaughlin, P. A. (2008), 'Do Economic Integration Agreements Actually Work? Issues in Understanding the Causes and Consequences of the Growth of Regionalism', *World Economy* **31**, 461–497.

Barrett, S. (1994), 'Self-enforcing international environmental agreements', *Oxford Economic Papers* **46**, 878–894.

Barrett, S. (1997), 'The strategy of trade sanctions in international environmental agreements', *Resource and Energy Economics* **19**, 345–361.

Barrett, S. (1998), 'On the theory and diplomacy of environmental treaty-making', *Environmental and Resource Economics* **11**(3-4), 317–333.

Barrett, S. (2001), 'International cooperation for sale', *European Economic Review* **45**(10), 1835–1850.

Barrett, S. (2006), 'Climate treaties and "breakthrough" technologies', *American Economic Review* **96**(2), 22–25.

Barrett, S. & Stavins, R. (2003), 'Increasing participation and compliance in international climate change agreements', *International Environmental Agreements: Policies, Law and Economics* **3**, 349–376.

Beron, K. J., Murdoch, J. C. & Vijverberg, W. P. (2003), 'Why cooperate? public goods, economic power and the montreal protocol', *The Review of Economics and Statistics* **85**(2), 286–297.

Brack, D. & Gray, K. (2003), Multilateral environmental agreements and the wto, Technical report, The Royal Institute of International Affairs and International Institute for Sustainable Development.

Bratberg, E., Tjøtta, S. & Torgeir, Ø. (2005), 'Do voluntary international environmental agreements work?', *Journal of Environmental Economics and Management* **50**, 583–597.

Cameron, A. C. & Trivedi, P. K. (2005), *Microeconometrics: Methods and applications*, Cambridge University Press, Cambridge et al.

Carraro, C., Marchiori, C. & Oreffice, S. (2009), 'Endogenous minimum participation in international environmental treaties', *Environmental and Resource Economics* **42**, 411–425.

Carraro, C. & Siniscalco, D. (1993), 'Strategies for the international protection of the environment', *Journal of Public Economics* **52**(3), 309–328.

Carraro, C. & Siniscalco, D. (1997), R&d cooperation and the stability of international environmental agreements, *in* 'International Environmental Agreements - Strategic Policy Issues', Edward Elgar Publishing, pp. 71–95.

Copeland, B. R. & Taylor, S. M. (2005), 'Free trade and global warming: A trade theory view of the kyoto protocol', *Journal of Environmental Economics and Management* **49**, 205–234.

Crozet, M., Head, K. & Mayer, T. (2011), 'Quality sorting and trade: Firm-level evidence for french wine', *Review of Economic Studies* p. forthcoming.

Endres, A. & Finus, M. (2002), 'Quotas may beat taxes in a global emission game', *International Journal of Tax and Public Finance* **9**, 687–707.

Feenstra, R. C. (2002), 'Border Effects and the Gravity Equation: Consistent Methods for Estimation', *Scottish Journal of Political Economy* **49**, 491–506.

Finus, M. (2003), Stability and design of international environmental agreements: The case of transboundary pollution, *in* H. Folmer & T. Tietenberg, eds, 'International Yearbook of Environmental and Resource Economics 2003/04', Edward Elgar Publishing, Cheltenham, UK, chapter 3, pp. 82–158.

Finus, M. (2008), 'Game theoretic research on the design of international environmental agreements: Insights, critical remarks and future challenges', *International Review of Environmental and Resource Economics* **2**, 29–67.

Finus, M. & Tjøtta, S. (2003), 'The oslo agreement on sulfur reduction in europe: The great leap forward?', *Journal of Public Economics* **87**, 2031–2048.

Fredriksson, P. G., Neumayer, E. & Ujhelyi, G. (2007), 'Kyoto protocol cooperation: Does government corruption facilitate environmental lobbying?', *Public Choice* **133**, 231–251.

Hallak, J. C. (2010), 'A Product-Quality View of the Linder Hypothesis', *Review of Economics and Statistics* **92**, 453–466.

Heckman, J. (1976), 'The common structure of statistical models of truncation, sample selection, and limited dependent variables and a simple estimator for such models', *Annals of Economic and Social Measurement* **5**, 475–492.

Hoel, M. & de Zeeuw, A. (2010), 'Can a focus on breakthrough technologies improve the performance of international environmental agreements?', *Environmental and Resource Economics* **47**, 395–406.

Hoel, M. & Schneider, K. (1997), 'Incentives to participate in an international environmental agreement', *Environmental and Resource Economics* **9**, 153–170.

Hoffmann, U. (2004), Specific trade obligations in multilateral environmental agreements and their relationship with the rules of the multilateral trading system - a developing country perspective, *in* 'Trade and Environment Review 2003', United Nations.

ITTA (1994), 'The international tropical timber agreement', UNCTAD document TD/TIMBER.2/16.

Murdoch, J. C. & Sandler, T. (1997), 'The voluntary provision of a pure public good: The case of reduced cfc emissions and the montreal protocol', *Journal of Public Economics* **63**, 331–349.

Murdoch, J. C., Sandler, T. & Sargent, K. (1997), 'A tale of two collectives: Sulfur versus nitrogen oxides emission reduction in europe', *Economica* **64**, 281–301.

Murdoch, J. C., Sandler, T. & Vijverberg, W. P. (2003), 'The participation decision versus the level of participation in an environmental treaty: A spatial probit analysis', *Journal of Public Economics* **87**, 337–362.

Qiu, L. D. & Zhihao, Y. (2009), 'Technology transfer and the south's participation in an international environmental agreement', *Review of International Economics* **17**(3), 409–427.

Rose, A. K. & Spiegel, M. M. (2009), 'Noneconomic engagement and international exchange: The case of environmental treaties', *Journal of Money, Credit and Banking* **41**(2-3), 337–363.

Wagner, U. J. (2001), 'The design of stable international environmental agreements: Economic theory and political economy', *Journal of Economic Surveys* **15**(3), 377–411.

Appendix

Modeling the probability and level of TT trading

The decision to participate in TT trading depends on the country i's firms operating profits and their fixed costs f_{ij} of serving the foreign market j. Note, overall profits of a country i's firm are assumed to be separable across importing countries. The profits that a typical country i firm earns in market j are then given by

$$\pi_{ij} = \tfrac{1}{\sigma-1} c_i \tau_{ij} x_{ij} - f_{ij}\theta_i. \tag{A1}$$

This implies that market j is served by country i whenever $\pi_{ij} \geq 0$. Since we assume that firms are always active in the domestic market this condition is equivalent to

$$\begin{aligned} \frac{c_i \tau_{ij} \left(\frac{p_i \tau_{ij}}{\theta_i^{\gamma_j}}\right)^{-\sigma} P_j^{\sigma-1} Y_j}{c_i \left(\frac{p_i}{\theta_i^{\gamma_i}}\right)^{-\sigma} P_i^{\sigma-1} Y_i} &\geq \frac{f_{ij}}{f_{ii}} \\ \frac{\tau_{ij}^{1-\sigma} \theta_i^{\sigma\gamma_j} P_j^{\sigma-1} Y_j}{\theta_i^{\sigma\gamma_i} P_i^{\sigma-1} Y_i} \frac{f_{ii}}{f_{ij}} &\geq 1 \end{aligned} \tag{A2}$$

using $\tau_{ii} = 1$ and $P_j^{1-\sigma} = \sum_{h=1}^{J} n_h \left(\frac{p_h \tau_{hj}}{\theta_h^{\gamma_j}}\right)^{1-\sigma}$. Based on equation (A2), we can formulate the latent variable for the propensity of firms from country i to serve market j as

$$\begin{aligned} &V_{ij}^* = (1-\sigma)\ln\tau_{ij} + \sigma(\gamma_j - \gamma_i)\ln\theta_i + \ln(P_j^{\sigma-1} Y_j) - \ln\left(P_i^{\sigma-1} Y_i\right) + \ln\left(\frac{f_{ii}}{f_{ij}}\right) \\ &V_{ij} = 1 \text{ if } V_{ij}^* > 0 \text{ and is unobserved otherwise} \end{aligned} \tag{A3}$$

Following Anderson & van Wincoop (2003), one can aggregate the value of the varieties that are produced in country i to obtain the total value of wood production denoted by Q_i. Using the condition that the expenditures on wood originating from country i aggregated over all the importing countries has to be equal to the production value Q_i, one obtains

$$Q_i = \sum_{h=1}^{J} X_{ih} = p_i^{1-\sigma} n_i \sum_{h=1}^{J} \left(\frac{\tau_{ih} V_{ih}}{\theta_i^{\gamma_h} P_j}\right)^{1-\sigma} Y_h \tag{A4a}$$

$$\Rightarrow \Pi_i^{1-\sigma} := \sum_{h=1}^{J} \left(\frac{\tau_{ih} V_{ih}}{\theta_i^{\gamma_h} P_j}\right)^{1-\sigma} \frac{\phi Y_h}{\phi Y} = \frac{Q_i}{\phi Y p_i^{1-\sigma} n_i} \tag{A4b}$$

$$p_i^{1-\sigma} n_i = \frac{Q_i \Pi_i^{\sigma-1}}{\phi Y} \tag{A4c}$$

with $\sum_{i=1}^{J} Q_i = \phi Y$. Using equations (A4a), (A4b) and (A4c), the total imports of TT of country j from country i can be described by

$$\begin{aligned} X_{ij} &= n_i \left(\frac{p_i \tau_{ij} V_{ih}}{\theta_i^{\gamma_j} P_j} \right)^{1-\sigma} \phi Y_j \\ &= \left(\frac{\tau_{ij} V_{ih}}{\theta_i^{\gamma_j}} \right)^{1-\sigma} P_j^{\sigma-1} \phi Y_j n_i p_i^{1-\sigma} \\ &= \left(\frac{\tau_{ij} V_{ih}}{\theta_i^{\gamma_j}} \right)^{1-\sigma} P_j^{\sigma-1} \phi Y_j \Pi_i^{\sigma-1} Q_i \frac{1}{\phi Y} \\ &= \left(\frac{\tau_{ij} V_{ih}}{\theta_i^{\gamma_j}} \right)^{1-\sigma} P_j^{\sigma-1} \Pi_i^{\sigma-1} \lambda_j \vartheta_i Y \phi \end{aligned} \tag{A5}$$

where $\lambda_j = Y_j/Y$ and $\vartheta_i = Q_i/\phi Y$. The trade resistance terms $\Pi_i^{1-\sigma}$ and $P_j^{1-\sigma}$ therefore simplify to

$$\Pi_i^{1-\sigma} = \sum_{h=1}^{J} \left(\frac{\tau_{ih} V_{ih}}{\theta_i^{\gamma_h} P_j} \right)^{1-\sigma} \lambda_h \tag{A6}$$

$$P_j^{1-\sigma} = \sum_{h=1}^{J} \left(\frac{\tau_{hj} V_{hj}}{\theta_h^{\gamma_j}} \right)^{1-\sigma} \Pi_i^{\sigma-1} \vartheta_i \tag{A7}$$

Taking logs of (A5), we obtain

$$\ln X_{ij} = (1-\sigma) \ln \tau_{ij} + (\sigma-1)\gamma_j \ln \theta_i + \ln(\lambda_j P_j^{\sigma-1}) + \ln\left(\vartheta_i \Pi_i^{\sigma-1}\right) + \ln(Y\phi) \quad \text{if } V_{ij} = 1 \text{ and } 0 \text{ otherwise} \tag{A8}$$

As highlighted above, product quality influences the probability as well as the level of trading TT. The econometric specification in the following Section is based on equation (A3) which describes the selection process and on equation (A8) that pictures the trade flows.

Table A1: Variable description and sources

Variable	**Description**	**Source**
X_{ijz}	Import value (in 1000 US$) of bilateral trade flow of tropical timber products z from exporter i to importer j.	UN Comtrade
V_{ijz}	Dummy variable = 1 if bilateral trade flow of tropical timber products z from exporter i to importer $j > 0$, 0 otherwise.	
RTA	Dummy variable = 1 if a regional trade agreement between the two trading partners is in force, 0 otherwise.	Baier et al. (2008); WTO
$Distance$	Distance (in km) between the main cities of the two trading partners.	CEPII
$Contiguity$	Dummy variable = 1 if the two trading partners share a common border, 0 otherwise.	CEPII
$Comlanguage$	Dummy variable = 1 if the two trading partners share the same language, 0 otherwise.	CEPII
$Colony$	Dummy variable = 1 if the two trading partners have ever had a colonial link, 0 otherwise.	CEPII
$Comcolonizer$	Dummy variable = 1 if the two trading partners have had a common colonizer after 1945, 0 otherwise.	CEPII
D_i	Dummy variable = 1 if exporter is ITTA-member, 0 otherwise.	Annex A and B of ITTA 1994
D_j	Dummy variable = 1 if importer is ITTA-member, 0 otherwise.	Annex A and B of ITTA 1994
D_iD_j	Dummy variable = 1 if both trading partners are ITTA members, 0 otherwise.	Annex A and B of ITTA 1994
y_j	Importer's GDP per capita in constant year 2000 US$.	World Bank (WDI)
y_i	Exporters's GDP per capita in constant year 2000 US$.	World Bank (WDI)

Table A2: Harmonized Commodity Description and Coding System 1996 (HS1996)

Code	Description
WOOD AND ARTICLES OF WOOD; WOOD CHARCOAL; CORK AND ARTICLES OF CORK; MANUFACTURES OF STRAW, OF ESPARTO OR OF OTHER PLAITING MATERIALS; BASKETWARE AND WICKERWORK	
44	WOOD AND ARTICLES OF WOOD; WOOD CHARCOAL
4403	**Wood in the rough, whether or not stripped of bark or sapwood, or roughly squared**
	Other, of tropical wood specified in subheading note 1 to this chapter:
440341	Dark red meranti, light red meranti and meranti bakau
440349	Other
4407	**Wood sawn or chipped lengthwise, sliced or peeled, whether or not planed, sanded or finger-jointed, of a thickness exceeding 6 mm**
	Of tropical wood specified in subheading note 1 to this chapter:
440724	Virola, mahogany (Swietenia spp.), imbuia and balsa
440725	Dark red meranti, light red meranti and meranti bakau
440726	White lauan, white meranti, white seraya, yellow meranti and alan
440729	Other
4408	**Veneer sheets and sheets for plywood (whether or not spliced) and other wood sawn lengthwise, sliced or peeled, whether or not planed, sanded or finger-jointed, of a thickness not exceeding 6 mm**
	Of tropical wood specified in subheading note 1 to this chapter:
440831	Dark red meranti, light red meranti and meranti bakau
440839	Other
4412	**Plywood, veneered panels and similar laminated wood**
	Plywood consisting solely of sheets of wood, each ply not exceeding 6 mm thickness:
441213	With at least one outer ply of tropical wood specified in subheading note 1 to this chapter
	Other, with at least one outer ply of non-coniferous wood:
441222	With at least one ply of tropical wood specified in subheading note 1 to this chapter

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Stefan Borsky, Andrea Leiter, Michael Pfaffermayr

Does going green pay off? The effect of an international environmental agreement on tropical timber trade

Abstract
Trade-related measures aim to regulate side-effects in international environmental agreements and are expected to positively influence the level of participation in the agreements as well as their degree of stability. In this paper we examine one side-effect of the 1994 International Tropical Timber Agreement - its impact on tropical timber trade. We use a cross-sectional dataset on bilateral trade flows of tropical timber that additionally contains information on trading partners' economic and geographical characteristics. Our empirical specification is based on a gravity equation, which is estimated using Heckman's selection model to address the potentially systematic selection of trading partners. We find significantly positive impacts of the 1994 ITTA on member countries' level of tropical timber trade. Furthermore, poor exporter countries benefit more from this trade enhancing effect than their richer counterparts.

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