The Leak in the System - Analyzing third country effects of an IEA on Tropical Timber Trade

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Abstract

This paper analyzes the magnitude and distribution of trade leakage due to an unilateral environmental conservation policy. In particular, we estimate the impact of the 1994 International Tropical Timber Agreement on the patterns of tropical timber trade flows. Trade leakage in international environmental agreements increases the ex-ante incentive to free-ride and therefore could lead to an under-provision of the global public good. 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. Overall, we find significant positive effects of the agreement on the propensity and intensity of tropical timber trade. Furthermore, we show that a small share in trade, 0.3%, shifts from the unregulated to regulated countries. The reason for this could be the dampening impact of the trade-measures, which are linked to the ITTA to reduce the extend of leakage

Keywords: International environmental agreements, trade leakage, pollution haven effect, product quality, sample selection.

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1 Introduction

Although international environmental agreements (IEAs) are often called global, generally only a subset of countries ratify the agreement or are subject to accompanying environmental regulations. The 1997 Kyoto Protocol on the reduction of greenhouse gases, for instance, has been ratified by 187 countries, but only 38 countries face binding greenhouse gas emission targets. These asymmetric conditions in IEAs, in which developed countries often face stricter environmental regulations than developing countries, are often a major concern in international negotiations. One argument is, that unilateral environmental policy may shift the comparative advantage of pollution intensive industries in regulated countries to industries in unregulated countries. The magnitude and direction of this shift, which is also known as trade leakage, is subject of several theoretical and empirical studies. But still, the empirical literature on leakage face some shortcomings and little is known about the magnitude and distribution of leakage due to unilateral conservation policy on a global level.

Here is where our analysis starts. We examine the effect of the 1994 International Tropical Timber Agreement (ITTA) on tropical timber (TT)[1] trade and determine the change in the trade patterns of TT for participating as well as non-participating countries. The aim of this study is twofold. First, motivated by the contributions of Murray, McCarl & Lee (2004) and Wear & Murray (2004) we analyze the impact of ITTA, which can be seen as an unilateral forest conservation policy, where only a fraction of the market participants is subject to this environmental regulation, on the propensity to trade TT and on the volume of trade in TT. Second, the disaggregation of this effect on individual country level allows us to examine the distribution and change of trade for participating as well as non-participating countries. We ask whether poor countries with a less stringent conservation policy, i.e. no ITTA membership, can increase their export of unsustainable TT due to a shift in comparative advantage from rich countries with a more stringent conservation policy, i.e. ITTA membership, to poor less regulated countries. This question is motivated mainly by the arguments related to the pollution haven effect (e.g. Copeland & Taylor 1994, Copeland & Taylor 2005).

Our identification strategy is based on a theoretical model of Hallak (2010) who highlights the importance of quality parameters in determining bilateral trade flows. The specification of the gravity model, which describes the bilateral trade flows in

[1] Following ITTA (1994) TT stands for 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. The term covers logs, sawnwood, veneer sheets and plywood.

TT, is based on the arguments in Anderson & van Wincoop (2003) and Anderson & Yotov (2010). We estimate the magnitude and distribution of the trade leakage due to ITTA using Heckman's selection model to control for the potential systematic selection of countries into the group of tropical wood traders. Our results show that countries, which sign the 1994 ITTA, are more likely to take part in TT trading and gain in the intensity of trade compared to countries, which have not signed the agreement. To determine the magnitude and distribution of the impact of ITTA on the trade patterns of TT trade, i.e. a potential trade leakage, we simulate a counterfactual world without the 1994 ITTA and compare it to the current status. Our simulation reveals a relatively small trade leakage effect, i.e. a shift in market share from regulated to unregulated exporting countries, of 1.0% in market share. Furthermore, we show that the market for TT separates, when ITTA enters into force: trade of TT with high environmental quality remains in the regulated and rich exporting countries, whereas the production of TT with low environmental quality leaks to poor countries with low environmental regulation. This supports the fundamental idea of the pollution haven effect.

This article extends the existing literature in several ways. Previous literature determines leakage effects either on a regional level (Wu 2000, Wu 2001, Murray et al. 2004, Wear & Murray 2004) or bases their discussion on simulation results (Sohngen, Mendelsohn & Sedjo 1999, Gan & McCarl 2007). To the best of our knowledge, this is the first empirical study, which examines the trade leakage effect of an unilateral conservation policy on a global level. Second, while some studies estimate leakage due to a change in trade patterns, which increase global pollution, only a few studies determine the magnitude and distribution of leakage in a setting with local and global pollution (e.g. Silva & Zhu 2009).[2] Forest conservation policies generally provide a local public good, for example a more stable and equally distributed water supply, and simultaneously a global public good, capturing CO_2 or balancing the global climate. This work aims at providing further insights into this quite unexplored field. Finally, the study of Borsky, Leiter & Pfaffermayr (2011) is based on a fixed effects panel regression, which does not exploit the country specific effects in detail, but only provides average measures of the effect of ITTA. This paper takes advantage of the complex empirical structure, which allows for determining multilateral resistance terms, i.e., the average trade barriers with all the relevant trading partners. Using this information we are able to determine ITTA's direct and indirect effect on TT trade by comparing each country's actual trade

[2] Contributions on global pollution are, for instance, studies on carbon leakage in the context of the 1997 Kyoto Protocol (e.g. Babiker 2001).

level and probabilty of trading with its hypothetical counterfactual where no ITTA membership exists at all.

The remainder of the paper is structured as follows. Section 2 provides information on the 1994 International Tropical Timber Agreement, discusses the background and existing literature on leakage and briefly summarizes the relevant literature on the pollution haven effect. In Section 3 we present the theoretical model and explain our empirical strategy. Section 4 describes our data and 5 discusses our results. Section 6 concludes.

2 Background and previous literature

Today, countries interact with each other on numerous issues in a complex manner. These interactions could be in a pure economic form, like international trade relations (e.g. WTO) or on non-economic topics, like international security (e.g. NATO) or transboundary environmental concerns through international agreements (Rose & Spiegel 2009). Some of these interactions lead to mutual reinforcement, while others interfere each other (Wagner 2001). Suppose, for example, that a country's production in a good is more costly due to an unilateral environmental policy. Then, under a free trade regime, for instance the WTO or NAFTA, the comparative advantage of these industries may shift to industries in countries, without this environmental policy. This phenomenon is known as trade leakage effect. If this reallocation takes place in countries with a dirtier production process, it will lead to a situation in which the provision of the global public good is less than the initial level of provision undertaken by the countries with the unilateral environmental policy. Furthermore, leakage increases the ex-ante incentive to free-ride if the free-riders' benefits from consumption of the public good, which countries under the unilateral environmental policy provide, and the gain in the world market share are sufficiently large (Barrett 1997).

Trade leakage is regularly a major concern in international environmental treaty negotiations and policy responses to reduce leakage can take various forms, ranging from tariffs and border tax adjustments to trade controls and trade sanctions (Frankel 2009). A prominent example of an IEA containing explicit policy measures to reduce the magnitude of leakage is the 1987 Montreal Protocol on substances that deplete the ozone layer. First, the agreement bans the import of ozone-depleting substances and goods incorporating them. And second, under the agreement member countries are called upon avoiding export of technology to produce and utilize controlled substances to non-participating countries. In contrast, the lack of measures

to control leakage under the 1997 Kyoto Protocol on the reduction of greenhouse gases is often seen as one reason of the low participation level (Barrett 1999). Another example of an IEA containing trade-related policy measures is 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 tropical timber.[3] To limit the extend of leakage the ITTA mainly makes use 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.

2.1 Explaining leakage

The recent scientific literature on leakage is based on the assumption that domestic and foreign emissions are strategic substitutes and therefore, unilateral emission reductions lead to an increase in emissions elsewhere. Our discussion follows Copeland & Taylor (2005) who where among the first who theoretically determine these effects in an open trading world using a perfectly competitive general equilibrium trade model that allows for global pollution. [4]

They start by decomposing a country's best response to a change in the world's environmental policy (i.e. a reduction of global pollution) into three effects: a free riding effect, a substitution effect, which includes the trade leakage effect, and an income effect. The free riding effect, which increases the amount of emissions, can be interpreted as the pure strategic effect of the unilateral foreign environmental policy on the domestic level of emissions holding the world price constant. Second, the effect of a change in the world price holding utility constant, can be divided into a substitution effect in production and an effect in demand. The effect in production is always positive as long as the economy is diversified, i.e. an increase in the price of the dirty good rises the producers' demand and this leads to a growth in the economy's pollution. For the consumers an increase in the price of the dirty good will always lead to a substitution towards environmental quality, due to the fact that it has become relatively cheaper. But as long as the dirty good is produced in the country, the substitution effect will always increase the domestic level of emissions as the price of the dirty good rises. Finally, the income effect of an increase in the

[3] For a 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).

[4] Most of the older literature on this topic analyzes these effects in a closed economy. See for example Felder & Rutherford (1993), Barrett (1997) and Robalino (2007).

price of the dirty good is again different for dirty good exporters and importers. For dirty good exporters an increase in price raises real income and – assuming that environmental quality is a normal good – emissions must fall. Otherwise, for the dirty good importers a rise in the price will decrease the real income and therefore increases the amount of emissions. Taking all three effects into account, the response of a country to an unilateral environmental policy is in an open world with free trade per se not clear. This is in contrast to the theoretical results assuming closed economies, where domestic and foreign environmental policies are always strategic substitutes.

Next to the theoretical contributions two strands of literature have developed that empirically analyze the size and distribution of trade leakage. First, there are several studies that examine the empirical magnitude of carbon leakage when greenhouse gas abatement is done unilateral (e.g. Felder & Rutherford 1993, Bernstein, Montgomery, Rutherford & Yang 1999, Babiker 2001, Babiker 2005, Bruvoll & Faehn 2006, Bruvoll & Faehn 2009). All authors find significant leakage effects of unilateral greenhouse gas abatement policies ranging in their estimated magnitude from small to considerably big.

The second strand of literature analyzes the size and distribution of trade leakage effects due to unilateral conservation policies, like forestry and agricultural land conservation, afforestation and deforestation policies. In an early study Sohngen et al. (1999) estimate the impact of a conservation policy, which protects 5% and 10% of forestland in North America and Europe respectively, on global timber markets using a computable general equillibrium modelling approach. They conclude that the average area of land, harvested in regions with no protection policy, increases by 1.4%. Furthermore, due to a higher world price the harvest in former inaccesible forest areas would increase by approximately 1 hectar for every 20 hectar conserved forest in North America and Europe. Wu (2000) and Wu (2001) determine analytically as well as empirically the effect of the US Conservation Reserve Program in the central United States and found that 20% of the protected area were replaced in an increase of agricultural production in not protected areas in this region.[5] Wear & Murray (2004) and Murray et al. (2004) study the impact of the 1973 Endangered Species Act to protect the habitat of the northern spotted owl in the major forests in the US Pacific Nordwest region on US and Canadian timber markets and production. Their results suggest that about 43% of reduction efforts

[5] Babcock, Zilberman & Wu (2001) conclude that due to such leakage effects cost-benefit analysis of individual projects tend to overestimate the net benefit and therefore, they recommend a more global assesment of such projects.

were additionally harvested in unprotected forests in the same region and 15% more in the rest of the US. Additional, Canada increases timber production by 26% due to the conservation policies in the US Pacific Nordwest region, which will lead to a grand total of 84% leakage rate. Gan & McCarl (2007) determine the magnitude and distribution of trade leakage due to a forest conservation policy on a global scale using computable general equillibrium modelling. They show that the leakage rate of an unilateral forest conservation policy is in the range between 42% and 95%. Furthermore, they estimate that between 21% and 75% of the forest conservation in devoloped countries will be offset by a production increase in developing countries.

2.2 The distribution of leakage

Standard theoretical literature on leakage due to an unilateral environmental policy does not address the distribution of leakage. This is of particular importance, especially in the political discussion, if the environmental harming effects of trade leakage are local and are distributed from the developing to the developed world. An often stated argument in this context is, that developing countries carry part of the abatement costs, including health costs, of environmental gains in developed countries. But in future these developing countries will have a smaller potential for exporting pollution and therefore, environmental improvements will come with higher abatement costs (Bruvoll & Faehn 2006, Bruvoll & Faehn 2009). Do get more information on the distribution of trade leakage, we base our arguments on the pollution haven theory, which is in their fundamental ideas quite similar to the discussion on leakage. The seminal paper of Copeland & Taylor (1994) was among the first who links country income levels to the stringency of environmental regulation and the ensuing trade patterns. Assuming that pollution is local and environment is a normal good, they show among other things that the stringency of environmental regulation rises with income and that under free international trade in goods a raise in the regulative stringency leads to a shift of dirty good production from the rich environmental regulated countries to the poor unregulated countries. This so called pollution haven effect has been subject of numerous theoretical as well as empirical contributions since the work of Copeland & Taylor (1994).[6] In contrast to earlier contributions, which are quite ambiguous in determining a statistical significant effect, the results in recent studies, which use panel data and fixed

[6] For a discussion on the difference between pollution haven effect and pollution haven hypothesis see Copeland & Taylor (2004). In this study we refer to the pollution haven effect, when we speak about differences in comparative advantage due to environmental policy.

effect estimation methods, suggest small but statistically significant pollution haven effects (e.g. Levinson & Taylor 2008).[7]

An alternative more conventional theory explaining the distribution of trade in dirty goods is known as factor endowments hypothesis (Copeland & Taylor 2004). According to this theory trade patterns are affected by standard forces, like differences in factor endowments or technology (e.g. Grossman & Krueger 1993, Zeng & Zhao 2009).

2.3 The International Tropical Timber Agreement

In 1986, after a long series of international negotiations, an international environmental agreement on the protection of the worlds' tropical forests - the so called International Tropical Timber Agreement (ITTA) - entered into force. Initially, it was signed by 36 producer and 34 consumer countries. Under the auspices of this agreement the International Tropical Timber Organization (ITTO), with its decision-making and recommendatory body, the International Tropical Timber Council, was established. The work of ITTO consists in developing internationally agreed policies to encourage sustainable forest management and forest conservation and to support member countries to adapt and implement such policies. Furthermore, ITTO collects, analyses and disseminates data on the production and trade of TT to strengthen the members' TT markets. Until now the original agreement was renegotiated two times, in 1994 as well as in 2006. In the 1994 ITTA, with the introduction of the 'ITTO Objective 2000' and the Bali Partnership Fund, the importance of the conservation objective increased substantially. The 1994 ITTA consists of 65 member countries, whereof the producing countries represent about 80 % of the world's tropical forests. The main objectives of the succeding ITTA 2006, which is not into force yet, are still the support of sustainable tropical forest management and the strengthening of TT markets.

3 Theoretical model and empirical specification

In this analysis we focus on the impact of product quality defined as sustainable produced TT on TT trade. Analogous to Hallak (2010) we distinguish between environmental quality in production θ and demand for environmental quality γ and suppose that both are positively related to the countries' GDP/capita. In particular, we assume that rich exporters have a comparative advantage in producing

[7] For an excellent overview see Copeland & Taylor (2004) and Cole (2004).

high environmental quality, while consumers in wealthy countries have a higher willingness to pay for environmental quality than people in poor countries. Aside this income variable, we introduce a further quality indicator, namely the exporters and importers ITTA status which is taken as a proxy for environmental concerns. We assume that the supply of (preferences for) environmental quality is higher, if the exporter (importer) has signed the ITTA.

Following Hallak (2010) as well as Anderson & van Wincoop (2003) and Anderson & Yotov (2010), we derive the following function for the nominal value of exports X_{ij} in TT from country i to country j:

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

According to equation (1), the volume of exports depends on bilateral iceberg-type transportation costs τ, on the quality parameters θ and γ on the multilateral trade resistance terms of the importer and exporter denoted by P_j and Π_i, respectively, and the fraction of GDP, ϕY, that is spent on TT. σ stands for the elasticity of substitution and the parameter V_{ij} is a dummy variable, which equals one for countries, which trade TT.

Anderson & van Wincoop (2003) show that the inclusion of the multilateral resistance terms P_j and Π_i in the gravity equation is crucial for achieving a theoretically correct estimate of the average trade barriers. P_j can be defined as price index at the demand side (weighted by the average distance and GDP), which is influenced by the remoteness of the respective importer from all its bilateral trading partners. Similarly, Π_i captures the price index at the supply side and depends on the exporter's bilateral distances to its trading partners. As Anderson & van Wincoop (2003) argue the multilateral resistance terms are not observed but can be determined by defining them as an implicit function of observable distance measures, such as geographical distance, common borders, and income shares. Alternatively, the multilateral resistance terms could be simply replaced by country specific dummies. Anderson & Yotov (2010) show how these multilateral trade resistances, which capture the relative (to the rest of the world) trading costs, can be used to determine the sellers' and buyers' incidence of bilateral trade costs.

The major contribution in this paper relies on these theoretical insights. By controlling for the multilateral resistance terms in the gravity equation we are able to determine the costs each country faces, if one specific country changes its quality

parameter, i.e., its status of its ITTA membership. In the paper, we refer to these cost incidences as trade leakage.

Moreover, in this analysis we consider that the selection of countries into the group of TT traders, i.e. $V_{ij} = 1$, may be systematic. We assume that the exporter i serves the import market j only if the operating profits from trading are at least as high as the fixed costs f_{ij} of serving market j. This leads to the specification of the latent variable V_{ij}^*, which describes the propensity of trading:

$$\begin{aligned} V_{ij}^* &= (1-\sigma)\ln\tau_{ij} + \sigma(\gamma_j - \gamma_i)\ln\theta_i + \ln(P_j^{\sigma-1}Y_j) - \ln\left(P_i^{\sigma-1}Y_i\right) + \ln\left(\frac{f_{ii}}{f_{ij}}\right) \\ V_{ij} &= 1 \text{ if } V_{ij}^* > 0 \text{ and is unobserved otherwise} \end{aligned} \tag{2}$$

Equation (2) shows that the probability of trading, i.e. V_{ij}, depends on similar parameters as the volume of exports X_{ij}. Considering that $\sigma > 1$ equation (2) implies that countries are less likely to trade the higher the bilateral transportation costs τ and the higher the fixed trade costs f_{ij} are. The selection further depends on the quality of production θ, the intensity of the consumers' preferences for quality γ, relative (to the rest of the world) trading costs captured by the multilateral resistance terms P_j and P_i, and the importers (exporters) income spent on the consumption (production) of TT.

In order to adequately implement the structural gravity equation in our econometric specification, we apply a Heckman sample selection model (Heckman 1976). We include exporter and importer fixed effects, which capture country specific trade resistances and quality parameters. The final estimation equation for the nominal exports X originated in country i shipped to country j reads as:

$$\begin{aligned} \ln X_{ij} = {} & a_0 + a_1(\ln y_j - \ln y_i)^2 + a_2 D_j \ln y_i + a_3 D_i \ln y_j + a_4 D_j D_i \\ & + a_5\tau_{ij} + c_i + m_j + \epsilon_{ij} \end{aligned} \tag{3}$$

where y_j (y_i) stands for the importer's (exporter's) GDP/capita. D_j (D_i) is an indicator variable, which equals one, if the importer (exporter) is an active ITTA member. Consequently, D_jD_i is one if the importer and the exporter signed the ITTA. The term, $(\ln y_j - \ln y_i)$, describes the deviation in the trading partners' GDP/capita (also known as Linder term, see Hallak (2010) for a discussion). The τ parameter captures several distance measures, namely the geographical distance between the trading partners' main cities, the existence of regional trade agreements (RTA) in force and whether the trading partners have a common border, a colonial

relationship, a common colonizer and/or a common language. c_i and m_j comprise the exporter and importer fixed effects and ϵ represents the error term.

The possibly systematic selection of countries into the group of TT traders (see discussion of equation (2)) is parameterized as follows:

$$\begin{aligned} \ln V_{ij}^{*} = b_0 + b_1(\ln y_j - \ln y_i)^2 + b_2 D_j \ln y_i + b_3 D_i \ln y_j + b_4 D_j D_i \\ + b_5 \tau_{ij} + c_i + m_j + \nu_{ij} \end{aligned} \tag{4}$$

where ν stands for the error term. The explanatory variables included are the same as in the trade volume equation.

The next section describes the data we rely on in order to empirically examine crucial factors that determine the intensity and probability of trading TT.

4 The data

4.1 Data description and modification

We attain our data from a number of sources. First, our main variable of interest, nominal bilateral tropical timber imports, is taken from the commodity trade statistic database of the United Nations. Our choice of traded product classes is based on the nomenclature of the Harmonized Commodity Description System 1996 (HS1996), which groups TT trade flows into 10 different codes on a 6 digit classification level and covers a period from 1996 to 2008.[8] Due to the fact that for some countries only a few trade flows per year and product class are observable, we collapse our sample over time and product class to get average values for this period. We start with a sample containing all exporting and importing countries, which reported at least one trade flow. As we want to analyze the impact of an unilateral forest conservation policy on the production and trade of TT, we drop all exporters, which are not tropical countries and therefore - by definition - cannot produce tropical timber.[9] This helps us to reduce the impact of intermediary trade flows. After these modifications our sample consists of 7,021 observations of which 1,630 observations include information on TT trade flows, i.e. imports of TT > 0.

Our explanatory variables contain following information. Data on geographical characteristics, which represents our trading costs, is taken from the CEPII Distances dataset and comprises the great circle distance between the economic

[8] For a detailed description of the product classes chosen, see Table A2 in the Appendix.
[9] For a definition of TT see Footnote 1 at the introduction of this article.

centers of the trading partners, common language, contiguity and colonial linkages. Information of trading partners' GDP/capita stems from the World Development Indicators (WDI 2009). To capture the extend of economic exchange between two countries we use a dummy variable (RTA) taken from Baier, Bergstrand, Egger & McLaughlin (2008) and from the WTO's Regional Trade Agreements Information System[10], which is 1, whenever a Regional Trade Agreement is in force. 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).[11]

4.2 Descriptive statistics

Table 1 reports descriptive statistics of the variables we use in our regressions. In our sample 119 importing and 72 exporting countries are involved in trading TT. The mean value of TT trade flows, i.e. import value of TT, amounts to 1,532,219 US$. The average GDP/capita (measured in constant year 2000 US$) of the TT importers is with 8,129 US$ more than twice as large as the average GDP/capita of the exporting countries. Burundi is with a GDP/capita of 110 US$ the poorest exporter as well as the poorest importer in our sample, whereas the richest exporter is Singapore with a GDP/capita of 24,641 US$ and the richest importer is Luxembourg with 47,607 US$. The mean distance between two trading partners is 8,655 km. Samoa and Mali with 19,904 km are the most distant trading partners. The fact that we allow countries to trade with themselves makes the inner-country trade flow at the Saint Vincent and the Grenadines with 7.4 km to the shortest distant one. In only 2% of the trade flows in our sample the trading partners share a common border. In 18% of the bilateral TT trade flows the countries have their language in common. In 12% of the observations they have (had) a common colonizer and in 1% the have (had) colonial links. Regional trade agreements are in force between trading partners in 18% of our observations. 39% (44%) of the importing (exporting) countries are members in the 1994 ITTA and in 17% of the cases both partners are ITTA members.

As we are interested in examining potential differences in the magnitude and distribution of trade-flows between rich/poor and regulated/unregulated countries, we split our sample according to ITTA membership and GDP/capita. We define countries as poor (rich), if their GDP/capita lies below (above) the 50th percentile. Table 2 compares the trade flows in TT between these country groups in percent

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

[11] Table A3 in the Appendix lists the countries, which are member of the ITTA 1994.

Table 1: Descriptive Statistics

Variable	Obs.	Mean	Std.Dev.	Min.	Max.
Imports (in 1,000 US$)	2296	1532.219	16523.450	0.009	611480
GDP/capita (importer)	8568	8128.609	10407.750	110.310	47608
GDP/capita (exporter)	8568	3218.557	5075.728	110.302	24641
Distance (in km)	8568	8655.097	4434.771	7.418	19904
Contiguity	8568	0.016	0.127	0	1
Com. language	8568	0.182	0.386	0	1
Colonial link	8568	0.009	0.094	0	1
Com. Colonizer	8568	0.120	0.326	0	1
Regional trade agreements	8568	0.178	0.383	0	1
ITTA (importer)	8568	0.403	0.491	0	1
ITTA (exporter)	8568	0.444	0.497	0	1
ITTA (both countries)	8568	0.179	0.384	0	1

of the total import value for each subgroup.[12] The grand totals of the subgroups sum up to a total import value of 3,518 million US$ (33+76+357+3,052). With a total amount of 3,052 million US$ the trade flows between countries, which are both ITTA members, accounts for 86.8% of this total TT value, whereas trade between countries, which are not members of ITTA, just amounts to 0.9% of all trade flows. The trade share of the subgroups where only the exporter (importer) is an ITTA member is 10.2% (2.2%) of the overall (3,518 million US$) trade volume. Hence, 97.0% (86.8%+10.2%) of the total value of TT trade stems from ITTA exporters. The value of TT imported by ITTA members amounts to 90.0% (2.2%+86.8%). Furthermore, 69.1% (76/(34+76)) of TT exports from unregulated countries, i.e. no ITTA membership, are shipped to regulated countries, i.e. ITTA members. With respect to GDP/capita we see that poor exporters of regulated countries are trading more than rich ITTA exporters independently of the importer's ITTA status (exempt the export value of ITTA exporter to poor ITTA importer). In the case of unregulated exporters we see that poor (rich) countries ship 21.3% (78.7%) of the TT to unregulated countries. Whereas in the case of regulated importers TT trade flows are with 57.5% of imports from poor exporters and 42.5% of imports from rich exporters more equally distributed.

[12] Subgroups (exporter/importer) are *No ITTA/No ITTA*, *No ITTA/ ITTA*, *ITTA/No ITTA* and *ITTA/ITTA*.

Table 2: Trade flows in TT in % of import value

Exporter		*Importer*					
		No ITTA			*ITTA*		
		Poor	Rich	Total	Poor	Rich	Total
No ITTA	Poor	11.05	10.21	21.26	34.66	22.84	57.49
	Rich	35.37	43.37	78.74	6.84	35.66	42.51
	Total	46.43	53.57	33479	41.50	58.50	75991
ITTA	Poor	20.09	34.55	54.64	5.89	48.23	54.12
	Rich	17.21	28.15	45.36	8.42	37.47	45.88
	Total	37.30	62.70	356837	14.30	85.70	3051668

Notes: Figures are based on the aggregate bilateral trade flows. Grand total of each subgroup in 1,000 US$. Total value of all imports (i.e. sum of grand totals) amounts to 3,518 million US$. Poor (rich) country, if country's GDP/capita is below (above) the 50th percentile.

While Table 2 just gives a picture on the distribution in average values for different subgroups, it does not allow to make any conclusions on the magnitude and distribution of the trade effects due to the unilateral environmental regulation, ITTA.In the following section we therefore econometrically analyze the distributional effects in more detail.

5 The results

The first question we address in our empirical analysis refers to the determinants, which shape the level and probability of TT trade. In order to control for the potential systematic selection of countries into the group of tropical wood traders, we apply Heckman's selection model. Table 3 depicts the results whereby the first (second) column reports the coefficients for the selection (outcome) equation.

First of all, the highly significant Mills ratio points at a systematic selection of countries in the group of tropical timber traders, which has to be controlled for to achieve unbiased estimates. In particular, all the distance parameters, which represent trade costs, significantly influence the probability of trading and behave as expected. The existence of a regional trade agreement, a common border, common language, common colonizer, and colonial links influence the probability of trading positively. The impact of the 1994 ITTA on the selection of trading partner is twofold: The probability of trading TT is higher, if both trading partners are ITTA members and increases with the importer's GDP/capita, given that the exporter is

Table 3: Trade flows in TT – estimation results

Independent variable	*Heckman's selection model*			
	selection		outcome	
	coeff.	std.error	coeff.	std.error
$D_i * D_j$	0.180*	0.100	0.564***	0.159
$D_i * \ln y_j$	0.108***	0.034	0.155***	0.052
$D_j * \ln y_i$	−0.008	0.036	−0.086	0.056
$(\ln y_i - \ln y_j)^2$	0.013**	0.006	−0.018*	0.009
RTA	0.219***	0.078	−0.120	0.119
$\ln distance$	−0.976***	0.045	−1.081***	0.070
contiguity	0.813***	0.171	0.269	0.205
comlanguage	0.356***	0.075	0.196*	0.116
comcolonizer	0.354***	0.093	0.236	0.153
colony	0.438*	0.226	0.412*	0.249
Mills ratio	0.647***			
F-tests				
Exporter and importer effects	8336.57***			
Observations	8513			

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

an ITTA member. But the ITTA membership does not only influence the probability of trading. It also determines the intensity of TT trade via several other channels. First, the volume of TT trade among trading partners is higher, if both countries have signed the 1994 ITTA. It increases with the importer's GDP/capita, given that the exporter has acceded to the 1994 ITTA. Otherwise, an increase in the exporter's GDP/capita, given that the importer has acceded to the 1994 ITTA, does not have a significant influence on the trade intensity. Furthermore, we find evidence of less TT trade the larger the distance between the trading partners and the more pronounced the deviation in their GDP/capita is.

These results, which form the basis of our comparative statics analysis, are in line with the findings in Borsky et al. (2011). This paper extends the work by Borsky et al. (2011) by allowing a more detailed analysis on the distribution of the trade effects induced by the ITTA (non-) membership. This makes a determination of potential trade leakage effects, which occur due to this unilateral conservation policy, possible.

In the following paragraphs, we examine the magnitude and distribution of the trade leakage. We estimate the total effects of ITTA on the countries' trade performance considering the actual status and the counterfactual share where we assume a world without any ITTA membership. This total change in trade flows due to an ITTA can be decomposed into two parts: ITTA's direct effect on trade and ITTA's effect on the price indices at the demand and supply market (i.e. the multilateral resistances Π_i and P_j) which we refer to as third country effects.[13]

Countries can considerably increase their trade volume by joining the ITTA. In the following, as the relative changes in trade volume are dependent on the country size we picture the ITTA induced trade effects as changes in the countries' world market share.[14] For the sake of clarity, we decide to show the trade effects due to ITTA for ITTA members as well as ITTA non-members.

We start with presenting the change in the ITTA exporters' trade share at the import markets which we average across the relevant exporters for each of the importing countries. Figure 1 illustrates the total changes in the ITTA exporters' trade shares by distinguishing between the importing countries' ITTA status. Shaded areas depict ITTA importers while the non shaded areas stand for non-ITTA importers. Figure 1 highlights that due to ITTA the ITTA exporters' world market share increased in the majority of the importing countries. These effects suggest that an improvement in the environmental quality in production can be seen like a reduction in prices so that the ITTA exporters are able to increase their world market share at the consumer market. Overall, the effects do not vary significantly across the importers' ITTA status. Based on these findings one can conclude that on average ITTA benefits those exporting countries that are ITTA members, as these countries are able to increase their world market share at the demand market. In other words, ITTA induces a shift of world export shares from non-ITTA exporters to ITTA exporters.

Figure 2 pictures the export shares of the tropical timber producers if the importing trading partner is an ITTA member. Exporters are separated by their ITTA status: (Non-)Shaded areas indicate (non)ITTA exporters. We find a heterogeneous effect of ITTA on the producers export shares. First, Figure 2 shows that – independent from the exporters' ITTA status – in several exporting countries the world export market shares remain unchanged indicating that ITTA does not effect the

[13] Third country effects can be defined as price adjustments of countries, which are not directly affected by the agreement.

[14] For example, an increase of 1% in the trade volume of a large exporter results in a higher change in the country's world market share than when a small exporter could increase its trade volume by 1 %.

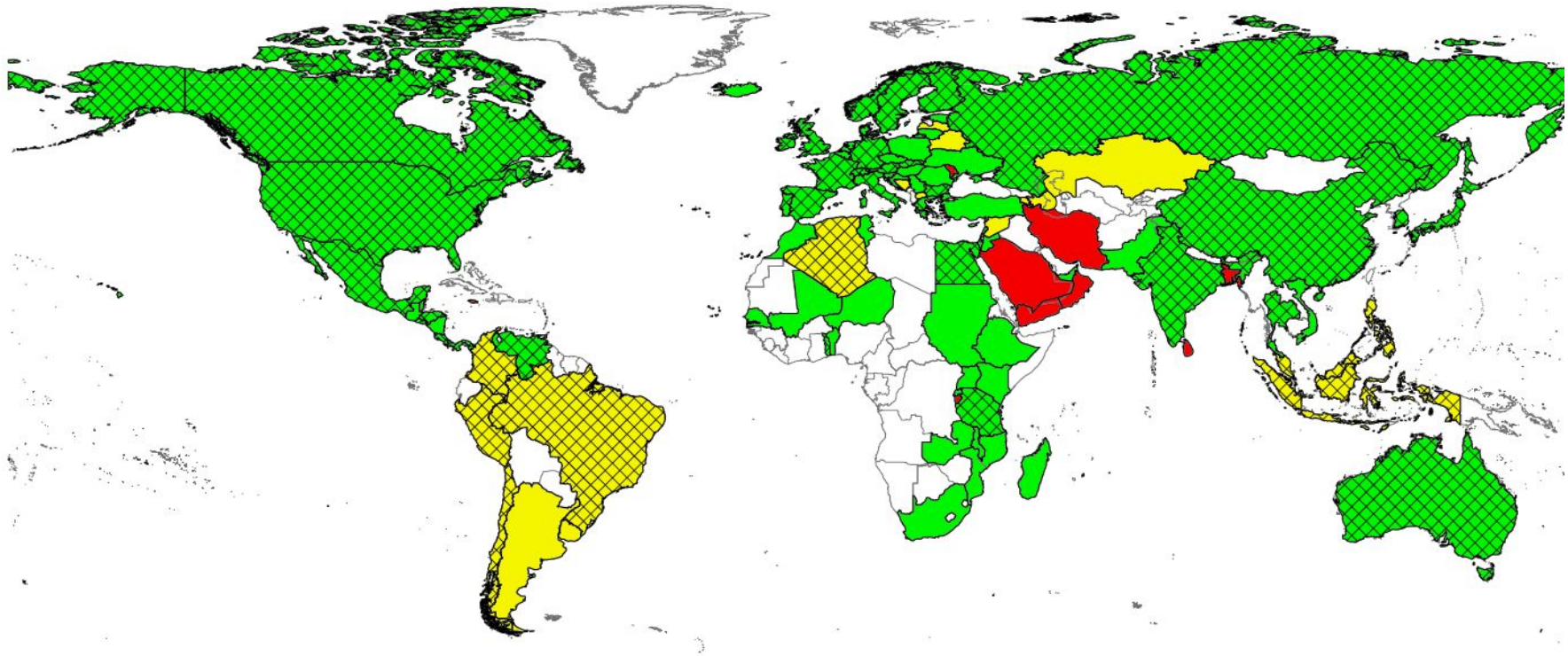

Figure 1: Changes in import shares due to ITTA – ITTA exporters

exporters' relative trade level. Second, China as well as some countries in Central and South America are able to increase their world market shares. These changes support the argument that countries which are able to produce high (environmental) quality can increase their export shares in importing countries that are ITTA members, i.e., that have a higher demand for (environmental) quality. Third, non ITTA members in Africa experience a decrease of their world export shares due to ITTA.

Figure 3 illustrates the export shares of the tropical timber producers given that the importer is not an ITTA member. As before, exporters are divided by their ITTA status: (Non-)Shaded regions indicate (non)ITTA exporters. Again, the ITTA induced changes of the exporters market shares are heterogeneous. A decrease in the producers' world export shares is observable for ITTA exporters in Asia. An explanation for this pattern is that importers which are not ITTA-members (and hence do not demand environmentally qualitative products) are not willing to pay higher prices for environmentally friendly produced products. Beneficiaries of ITTA are Australia, Central and South America as those exporters mostly experience an increase in their world export shares. In Africa, the ITTA induced changes in the exporters world market share are most diverse.

Overall, the ITTA induced changes of the exporters' world market shares are rather homogeneous when looking at the import markets but are much more diverse if one focus at the respective changes at the export markets.

In a further step in Table 4 we summarize the ITTA's direct and total effect on the trade share by the countries' agreement status. The upper panel of Table 4 highlights that the direct impact of ITTA considerably increases the trade shares of the regulated (ITTA) exporters. In particular, the average increase in the exporters' world market trade share due to ITTA's direct impact amounts to 39.5%. It is lower (higher) if the TT is shipped to a unregulated (regulated) importer (37.2% vs. - 41.8%). The perfect mirror-image is observed for the unregulated (ITTA) exporters: Their trade share decreases by 39.5 % on average. While the direct effect of an unilateral conservation policy clearly depicts a shift of the market share from unregulated countries to regulated countries, the magnitude and distribution of the total effect is per se not clear. As highlighted in Anderson & van Wincoop (2003) and Anderson & Yotov (2010), multilateral resistance terms, which capture the average trade barriers of the two trading countries with all their other trading partners, are a crucial determinant of bilateral trade flows. Hence, to determine the total effect of ITTA we therefore have to include the agreement's indirect effect on TT trade through a change in the price index at the demand and/or supply side.

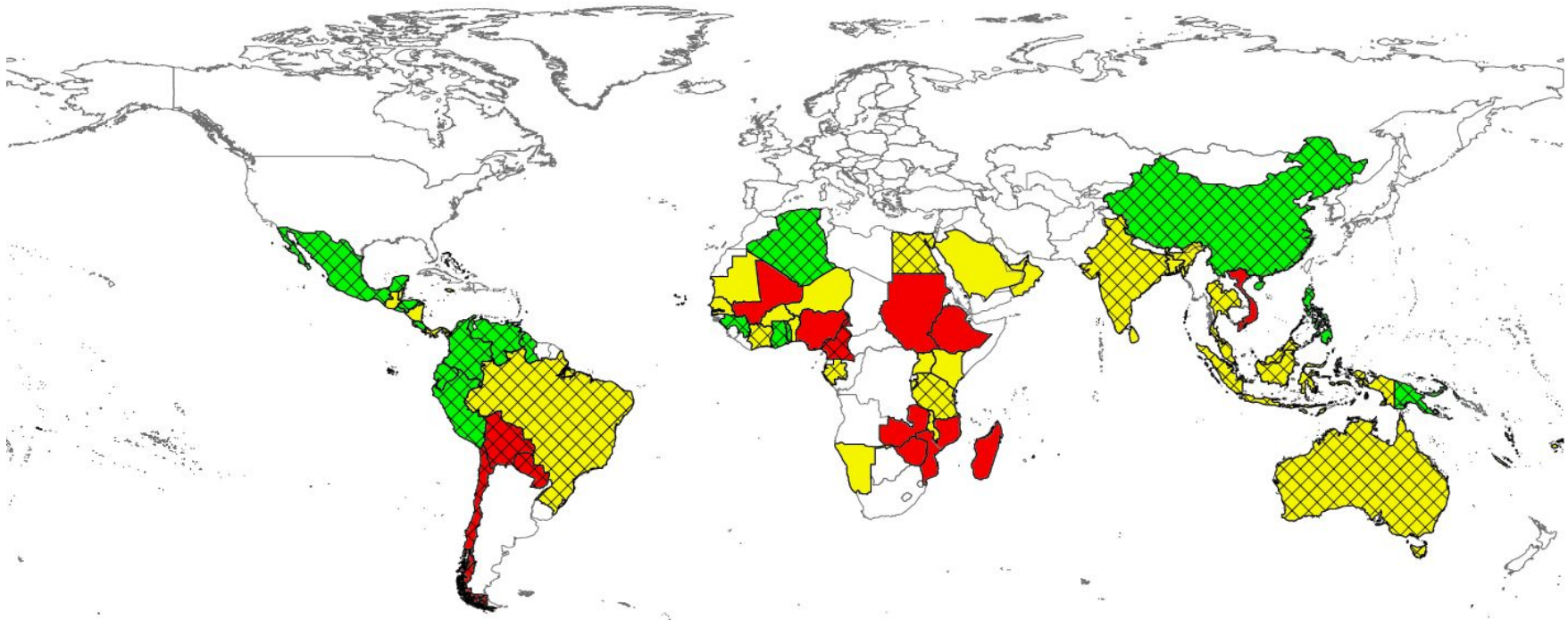

Figure 2: Changes in export shares due to ITTA – non ITTA importers

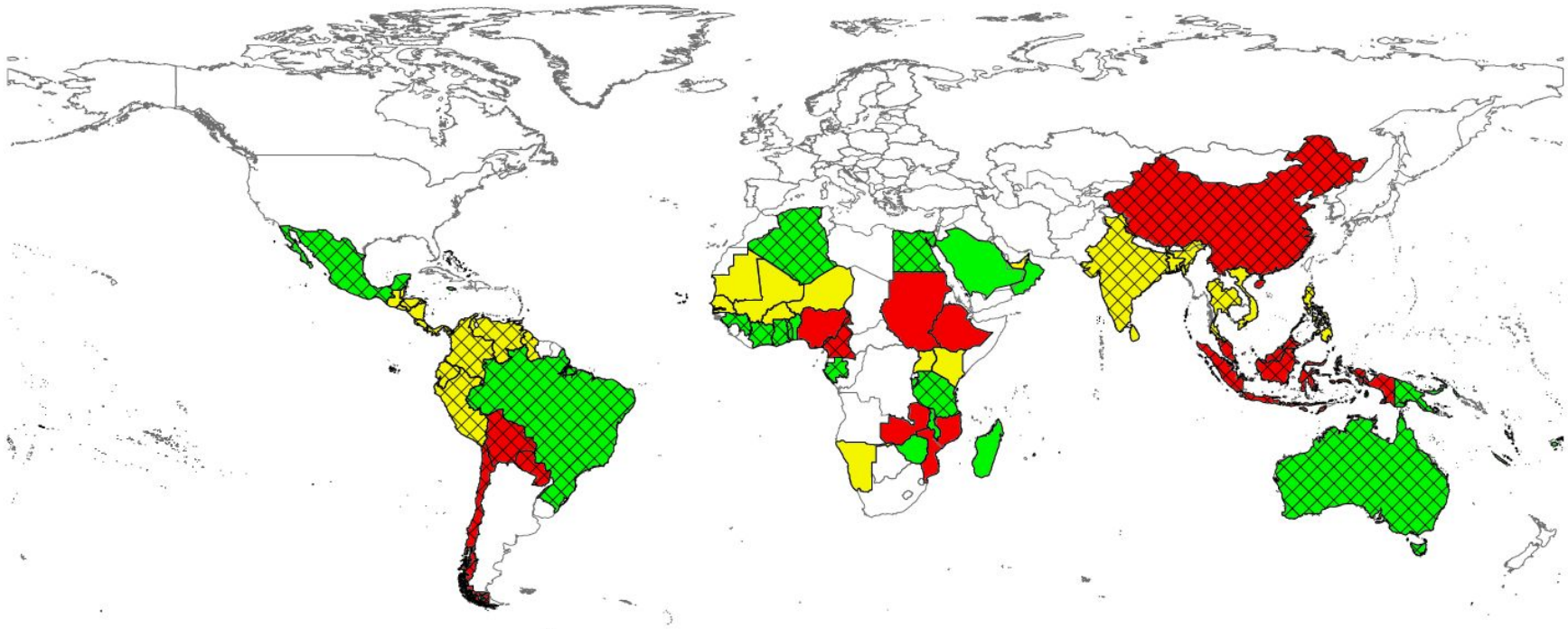

Figure 3: Changes in export shares due to ITTA – ITTA importers

For example, signing the ITTA may reduce a country's trade cost which is assumed to equal an increase in quality at given prices. Higher environmental quality and/or lower prices induce higher demand. Given, that the supply of TT is fixed this results in a higher import price for TT so that the market is cleared again. Taking the price effects into account changes the strong direct effect of ITTA considerably. The lower panel of Table 4 nicely shows that regulated ITTA exporters can still expand their trade shares but that the effect is significantly moderated due to the price effects: Compared to the counterfactual world without an agreement, the existence of ITTA leads to an average increase by 0.3% in the trade shares of the regulated exporters. Further, the trade share in unregulated importing countries is slightly higher compared to regulated importers.

Table 4: Direct and total trade effect of ITTA membership by ITTA status

		Importer		
Exporter		No ITTA	ITTA	mean effect
ITTA	*Direct effects*	xxx	xxx	xxx
ITTA	*Total effects*	xxx	xxx	xxx

To analyze the distribution of trade leakage in more detail, we summarize these outcome for the 4 country groups (ITTA vs. non-ITTA members; rich vs. poor countries) in two steps. Again, in Table 5, we start with discussing the ITTA's direct impact on the world's TT trade. The direction of the effect of ITTA is quite uniform. By the time ITTA enters into force all unregulated exporter countries lose market share, whereas the exporters, which signed ITTA, gain in market share. Distinguishing between the different groups of importers, i.e. ITTA member/no ITTA member and rich/poor countries, we find that poor unregulated exporting countries lose between -21.6% and -36.2% of market share in poor importer markets depending on their ITTA status. In case of rich unregulated exporters our results show that the loss of market share in poor importer markets is with -1.2% and -6.4% considerably less compared to the poor unregulated exporting countries. Further, rich unregulated exporting countries lose with -2.3% and -1.2% less market share in rich importing countries compared to poor unregulated exporting countries with -28.8% and -38.9% respectively. In the case of regulated exporting countries the increase is in general higher in unregulated than in regulated importing markets.

Further, rich regulated exporting countries face a higher increase in market share in both import markets: the regulated as well as the unregulated.

Again, due to price adjusting effect we do not know the magnitude and distribution of the total ITTA effect per se. Therefore, we have to take multilateral resistance terms into account when calculating the total effect. Table 8 presents the total effects of an implementation of ITTA on TT trade on the market share of the different country groups.

Table 5: Direct trade effect of ITTA membership

Exporter		*Importer*			
		ITTA		*No ITTA*	
		Poor	Rich	Poor	Rich
ITTA	Poor	24.881	10.992	15.081	6.821
	Rich	11.692	33.262	9.107	14.567
No ITTA	Poor	-34.638	-41.447	-20.568	-20.741
	Rich	-1.934	-2.807	-3.620	-0.647

Notes: Poor (rich) country, if country's GDP/capita is below (above) the 50th percentile. Trade effects are defined as change in market shares and are measured in percentage points.

Table 6: Leakage effect of ITTA membership

Exporter		*Importer*			
		ITTA		*No ITTA*	
		Poor	Rich	Poor	Rich
ITTA	Poor	-27.776	-10.494	-15.027	-8.657
	Rich	-13.113	-32.501	-15.238	-16.195
No ITTA	Poor	38.836	40.368	25.901	24.372
	Rich	2.053	2.628	4.364	0.481

Notes: Poor (rich) country, if country's GDP/capita is below (above) the 50th percentile. Trade effects are defined as change in market shares and are measured in percentage points.

Compared to the direct effect our results of the total effect pictures the dampening effect of the price adjustments of the exporting countries and the strength as well as the direction of the effect is not that uniform anymore. First, we start by analyzing the effect of ITTA on the group unregulated exporters. We find that poor unregulated exporters gain market shares rich regulated importer markets, whereas

Table 7: Total trade effect of ITTA membership

Exporter		*Importer*			
		ITTA		*No ITTA*	
		Poor	Rich	Poor	Rich
ITTA	Poor	-2.895	0.498	0.054	-1.836
	Rich	-1.421	0.761	-6.131	-1.628
No ITTA	Poor	4.197	-1.079	5.334	3.630
	Rich	0.119	-0.180	0.743	-0.166

Notes: Poor (rich) country, if country's GDP/capita is below (above) the 50th percentile. Trade effects are defined as change in market shares and are measured in percentage points.

in all other import markets the change is less than 1%. The market share of rich unregulated exporting countries stays relatively stable with a change between -0.1% and 0.7%.

In the case of the group of poor regulated exporting countries, with -5.8% to 0.7% they loose market share all importing markets. The rich regulated exporting countries, which serve an ITTA import market are able to increase their market share by 5.9% and 3.0% respectively. In regulated importing markets the rich regulated exporter lose market share by -4.8% and 0.2%.

Table 8: Price incidence of ITTA membership

		Levels		*Changes*	
		No ITTA	ITTA	No ITTA	ITTA
Importer	Poor	1.010	1.339	-0.256	7.786
	Rich	1.224	1.397	-9.706	6.636
Exporter	Poor	11.958	25.956	-34.693	8.294
	Rich	12.564	22.918	-35.201	4.134

Notes: Poor (rich) country, if country's GDP/capita is below (above) the 50th percentile.

Finally, in Table 9 we depict the impact of ITTA on the probability of trading TT for the different country groups. By the time ITTA enters into force, the probability to start TT trading decreases for almost all unregulated countries, independently of the import market they are serving. In contrast, for regulated exporting countries the probability to start TT timber trading increases independently of the import

market. Again, the reason for this shift in probability could be that ITTA member countries form an exclusive club, which excludes the trade with non-ITTA countries.

Table 9: Change in propensity of trading due to ITTA membership

Exporter		*Importer*			
		ITTA		*No ITTA*	
		Poor	Rich	Poor	Rich
ITTA	Poor	0.013	0.041	0.126	0.237
	Rich	0.043	0.035	0.105	0.205
No ITTA	Poor	-0.009	-0.010	0.000	0.000
	Rich	-0.004	-0.013	0.000	0.000

Notes: Poor (rich) country, if country's GDP/capita is below (above) the 50th percentile.

6 Conclusions

Trade leakage is often a major concern in IEA negotiations. At best, when IEAs face full participation rates, i.e. all countries join the agreement, and consist of uniform stringency in environmental regulation, leakage would not occur. But regularly IEAs comprise only a subset of countries, which have ratified the agreement or are subject to environmental regulations. Knowledge of leakage rates due to unilateral environmental policy helps to reduce the consequential problems of leakage, i.e. a low participation rate and an under-supply of the global public good, by designing appropriate policy instruments in IEAs.

This paper examines the magnitude and distribution of trade leakage in TT trade caused by the forest conservation policies in ITTA. First, we present that due to accession to the ITTA the probability to trade as well as the average trade intensity of TT rises significantly for signatory countries compared to countries, which have not signed the ITTA. Furthermore, we show that GDP/capita of the trading partners play an important role in the propensity and size of TT timber trade. To determine potential trade leakage effects we simulate a counterfactual world without the unilateral forest conservation policy, i.e. no ITTA, which allows analyzing the impact of ITTA on the patterns of TT trade. Our estimation results reveal a shift in the market share in TT trade from unregulated to regulated countries. The magnitude of this trade shift is, with 0.3%, relatively small and in the opposite di-

rection compared to other studies, which analyze the magnitude of leakage due to an unilateral forest conservation policy (e.g. Murray et al. 2004, Gan & McCarl 2007). The reason for this could be the dampening impact of the trade-measures, which are linked to the ITTA to reduce the extend of leakage (see Chapter 2). In a further step, we distinguish between the ITTA status as well as the GDP/capita of the importing and exporting countries. The direct effect of ITTA depicts a clear shift from the unregulated exporting countries to the regulated exporting countries, independently of the importer's GDP and ITTA status. Taking the price effects into account reduces this rather strong effect considerably. But, a specific pattern in the distribution of trade between rich and poor and regulated and unregulated countries is not observable in the total effects. Due to the rather strong price effects we expect to be able to observe a specific pattern in the distribution of this effect. This will be done in a further step.

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Appendix

Table A1: Variable description and sources

Variable	**Description**	**Source**
X_{ij}	Import value (in 1000 US$) of bilateral trade flow of tropical timber from exporter i to importer j.	UN Comtrade
V_{ij}	Dummy variable = 1 if bilateral trade flow of tropical timber 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.	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 2000 US$.	World Bank (2009) WDI
y_i	Exporters's GDP per capita in constant 2000 US$.	World Bank (2009) 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

Table A3: List of 1994 ITTA member countries

Producer countries	
Bolivia	Indonesia
Brazil	Liberia
Cameroon	Malaysia
Colombia	Mexico
Congo	Myanmar
Costa Rica	Panama
Cote d'Ivoire	Papua New Guinea
Dominican Republic	Paraguay
Ecuador	Peru
El Salvador	Philippines
Equatorial Guinea	Thailand
Gabon	Togo
Ghana	Trinidad and Tobago
Guyana	United Republic of Tanzania
Honduras	Venezuela
India	Zaire
Consumer countries	
Afghanistan	Italy
Algeria	Netherlands
Australia	Portugal
Austria	Spain
Bahrain	United Kingdom
Bulgaria	Finland
Canada	Japan
Chile	Nepal
China	New Zealand
Egypt	Norway
Belgium	Republic of Korea
Luxembourg	Russian Federation
Denmark	Slovakia
France	Sweden
Germany	Switzerland
Greece	United States of America
Ireland	